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U.S. Department of the Interior
Bureau of Reclamation

Final Biological Assessment

The Effects of the Proposed Action to Operate the Klamath Project from April 1, 2013 through March 31, 2023 on Federally-Listed Threatened and Endangered Species

Mid-Pacific Region

U.S. Department of the Interior
Bureau of Reclamation

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Mission Statements

The mission of the **Department of the Interior** is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the **Bureau of Reclamation** is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover photo: Link River Dam with Upper Klamath Lake in the background.

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Klamath Basin Area Office
Mid Pacific Region

EXECUTIVE SUMMARY

This Biological Assessment (BA) has been prepared pursuant to section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended, (16 U.S.C. § 1531 *et seq*.), to evaluate the potential effects of the continued operation of the Bureau of Reclamation's (Reclamation) Klamath Project on species listed as threatened or endangered under the ESA. The Project is located in south-central Oregon and northeastern California and contains approximately 200,000 acres of irrigable land. Reclamation stores, diverts, and conveys waters of the Klamath and Lost rivers to meet authorized Project purposes and contractual obligations in compliance with state and federal laws and carries out the activities necessary to maintain the Project and ensure its proper long-term functioning and operation.

Federally-listed species that may occur within the Action Area and considered as part of this consultation are the endangered Lost River sucker (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes brevirostris*), threatened Southern Oregon/Northern California Coast (SONCC) coho salmon *(Oncorhynchus kisutch)*, threatened Southern Distinct Population Segment (DPS) of the North American green sturgeon (*Acipenser medirostris*), endangered Southern Resident DPS killer whale (*Orcinus orca*), and threatened DPS of Pacific eulachon (*Thaleichthys Pacificus*).

This BA describes Reclamation's proposed operation of the Project from April 1, 2013, through March 31, 2023. The Proposed Action consists of three major elements: (1) the storage and diversion of Klamath River and Lost River water and the management of return flows; (2) operation of the Klamath Project for the delivery of water for irrigation and related purposes; and (3) the performance of activities necessary to maintain the Klamath Project to ensure its proper long-term functioning and operation.

Reclamation has considered the best scientific and commercial information available and determined the potential effects of the Proposed Action on federally-listed species. This analysis shows that the Proposed Action may affect, and is likely to adversely affect Lost River and shortnose suckers and SONCC coho salmon. This analysis also indicates that proposed critical habitat for the suckers is not likely to be adversely affected and designated critical habitat for the coho salmon is likely to be adversely affected. The analysis further demonstrates that the Proposed Action may affect, but is not likely to adversely affect the Southern DPS North American green sturgeon, the Southern Resident DPS killer whale, and the Southern DPS of Pacific eulachon, and is not likely to adversely affect designated critical habitat for the Southern DPS of Pacific eulachon.

Based on these conclusions, Reclamation is requesting formal consultation under section 7(a)(2) of the ESA with the USFWS on the Lost River and shortnose suckers and their proposed critical habitat, and with NMFS on the coho salmon and their designated critical habitat, the Southern DPS North American green sturgeon, the Southern Resident DPS killer whale, and the Southern DPS Pacific eulachon and its designated critical habitat.

ACRONYMS AND ABBREVIATIONS

AF	acre-feet
ACT	Agency Coordination Team
AFA	Aphanizomenon flos-aquae
BA	Biological Assessment
BO	Biological Opinion
BOD	biochemical oxygen demand
°C	degrees Celsius
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
Copco	California Oregon Power Company
DPS	Distinct Population Segment
DO	dissolved oxygen
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
EWA	Environmental Water Account
°F	degrees Fahrenheit
feet/s	feet per second
FASTA	Flow Account Scheduling Technical Advisory Team
FERC	Federal Energy Regulatory Commission
FR	Federal Register
HCP	Habitat Conservation Plan
HID	Horsefly Irrigation District
IGD	Iron Gate Dam
KBAO	Klamath Basin Area Office
KBPM	Klamath Basin Planning Model
KID	Klamath Irrigation District
LKNWR	Lower Klamath National Wildlife Refuge
LRDC	Lost River Diversion Channel
LVID	Langell Valley Irrigation District
m	meter
mg/L	milligrams per Liter
µg/L	micrograms per Liter
mm	millimeter
msl	mean sea level
NMFS	National Marine Fisheries Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NWR	National Wildlife Refuge
ODEQ	Oregon Department of Environmental Quality
O&M	Operation and Maintenance

PIT	Passive Integrated Transponder
Project	Klamath Project
Reclamation	U.S. Bureau of Reclamation
RM	river mile
Secretary	Secretary of the Interior
SONCC	Southern Oregon/Northern California Coast
Stat.	Statute
STAT	Scientific Technical Advisory Team
TAF	thousand acre-feet
TID	Tulelake Irrigation District
TL	total length
TMDL	total maximum daily load
UKL	Upper Klamath Lake
U.S.	United States
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRIMS	Water Resource Integrated Modeling System
YOY	Young-of-the-Year

CONTENTS

Contents

Appendices

Figures

Tables

Part 10

Part 1 INTRODUCTION

1.1. Purpose of the Biological Assessment

The United States (U.S.) Bureau of Reclamation (Reclamation) proposes to continue to operate the Klamath Project (Project) to store, divert, and convey water to meet authorized Project purposes and contractual obligations in compliance with applicable state and federal law and carry out the activities necessary to maintain the Project and ensure its proper long-term functioning and operation.

To evaluate the potential effects to federally-listed species that could result from the continued operation and maintenance (O&M) of the Project, Reclamation has prepared this Biological Assessment (BA) pursuant to section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. section1531 *et seq*.). Reclamation has determined that reinitiation of consultation (50 Code of Federal Regulations (C.F.R.) section 402.16) is warranted due to an adjustment to Project operations and new scientific information related to the effects of Project operations on listed species.

This BA provides information on the anticipated effects of the Proposed Action that cover the period from April 1, 2013 through March 31, 2023 on federally-listed species for use by the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS; collectively referred to as the Services). Reclamation and the Services extensively collaborated during informal consultation and in the development of the BA. As a result, Reclamation has prepared a single BA to initiate section 7(a)(2) consultation with both agencies in order to facilitate further coordination between the Services. In informal consultation, USFWS and NMFS indicated they would prepare a joint Biological Opinion (BO).

1.2. Klamath Project Description

The Project provides water to approximately 200,000 acres of irrigable land and is located in south central Oregon and northern California. The Project encompasses lands in Klamath County, Oregon and Siskiyou and Modoc counties, California. Communities in the vicinity of the Project include Tule Lake, California and Klamath Falls, Bonanza, Merrill, and Malin, Oregon. Project facilities in Oregon consist of Upper Klamath Lake (UKL), Link River Dam, Gerber Dam and Reservoir, and the Lost River, Miller, Malone, and Anderson-Rose diversion dams. Project facilities in California consist of Clear Lake Dam and Reservoir, Tule Lake, and Lower Klamath Lake (*See* Figure 1-1 and Appendix 1A).

The Project's water supply comes from the Klamath and Lost River basins and is stored in UKL and Clear Lake and Gerber reservoirs. The Project consists of a complex network of storage and conveyance features including reservoirs, lakes, dams, diversion dams, rivers, canals, and drains. The Project can be split into two distinct parts, the West and East sides. Water releases made from East Side dams are typically not used to provide water for the West Side and water diverted from UKL for irrigation on the West Side is not used in the East Side due to facility limitations.

The West Side encompasses three large irrigation districts, several small irrigation districts, and two National Wildlife Refuges (NWRs) which are all served by water stored in UKL. The three large irrigation districts included within the West Side area are Klamath Irrigation District (KID), Tulelake Irrigation District (TID), and Klamath Drainage District (KDD).

The East Side of the Project consists of two irrigation districts, Langell Valley Irrigation District (LVID) and Horsefly Irrigation District (HID). Reclamation operates Clear Lake and Gerber reservoirs to provide irrigation water to landowners within LVID, HID and other Project water users.

1.3. Overview of Klamath Project Operations

Legal and statutory authorities and obligations, water rights, and contractual obligations have informed and shaped Reclamation's Proposed Action. This section of the BA elaborates on those authorities, responsibilities, and obligations.

1.3.1. Legal and Statutory Authorities

The Project is one of the earliest federal reclamation projects. The Act of February 9, 1905 (33 Stat. 714), authorized the Secretary of the Interior (Secretary) to change the level of several lakes and to dispose of certain lands that were later included in the Project. The Oregon and California legislatures, on January 20 and February 3, 1905, respectively, passed legislation ceding certain lands to the United States (U.S.) for use as Project lands[1]. The Project was authorized by the Secretary on or about May 15, 1905, in accordance with the Reclamation Act of 1902 (Pub. L. No. 57-161, 32 Stat. 388 (codified as 43 U.S.C. § 371 *et seq.*)), and approved by President William Howard Taft on January 5, 1911, pursuant to the Advances to the Reclamation Fund Act of 1910 (36 Stat. 835).

The Secretary's authorization provided for the construction of Project works in order to: drain and reclaim lakebed lands of the Lower Klamath and Tule lakes; store waters of the Klamath and Lost rivers, including storage of water in Lower Klamath and Tule lakes; divert stored water for irrigation purposes; and control flooding of reclaimed lands.

1.3.2. Water Rights

Federal law requires that Reclamation obtain water rights for its projects and administer its projects pursuant to state law relating to the control, appropriation, use or distribution of water for irrigation purposes, unless the applicable state laws are inconsistent with express or clearly implied congressional directives. 43 U.S.C. § 383; California v. United States, 438 U.S. 645, 678 (1978); appeal on remand, 694 F.2d 117 (1982). Water can only be stored and delivered by the Project for authorized purposes for which Reclamation has asserted or obtained a water right in accordance with Section 8 of the Reclamation Act of 1902 (43.U.S.C. § 383) and applicable federal law. On May 19, 1905, pursuant to then-applicable Oregon state law, Reclamation filed notice with the State Engineer of Oregon claiming "all the waters of the Klamath Basin in Oregon consisting of the entire drainage basins of the Klamath River and Lost River … and their

[1] *See* 1905 Or. Laws, p. 63; 1905 Cal. Stat., p. 4.

tributaries." Similar notices of water rights were filed in California for water from the Lost River and its tributaries. All Project lands are covered by water rights with the same priority date.

The water rights for the Klamath Project have yet to be adjudicated and judicially decreed pursuant to Oregon law. Oregon is currently in the process of finalizing the Klamath Basin General Stream Adjudication, which will ultimately result in the issuance of water right certificates for the use of water from the Klamath River watershed.

Reclamation has an obligation to deliver water to the Project water users in accordance with claimed Project water rights and contracts between Reclamation and the water users (which may be through a water district), subject to the availability of water. Reclamation must also operate the Project in a manner so as not to impair water rights that are senior to the Reclamation claimed right.

In certain circumstances, Reclamation may be unable to deliver water for Project purposes due to shortages or other reasons. *See* Sections 1.3.8., Endangered Species Act, and 1.3.9., Tribal Water Rights and Trust Resources. *See also*, for example, Klamath Water Users Assoc. v. Patterson, 204 F. 3d 1206 (9th Cir. 2000) and Kandra v. United States, 145 F. Supp. 2d 1192 (D. Or. 2001).

1.3.4. Klamath Project - Repayment Contracts

Project water, water stored or diverted for Project purposes, is delivered to Project contractors pursuant to various contracts with Reclamation. The contracts do not always specify a particular amount of Project water to be provided on an annual basis, but rather create an obligation for Reclamation to deliver available Project water for beneficial use on specified lands. In all, over 250 repayment contracts are administered either directly or through irrigation districts on the Project.

Reclamation has entered into various types of contracts with water users for Project water. The most common type are "repayment contracts", which generally obligate the water user to repay Reclamation for a portion of the construction costs associated with Project water distribution and/or supply facilities. Reclamation has also entered into numerous contracts for Project water pursuant to the Warren Act of 1911 (43 U.S.C. §§ 523-525). Generally, these contracts provide water users with a permanent right to Project waters, depending on availability. In addition, Reclamation has contracted with certain irrigation districts for the Operation and Maintenance (O&M) of certain Project facilities. Such districts include KID, TID, and LVID.

1.3.5. Klamath Project - Temporary Water Contracts

On a year to year basis, Reclamation has discretion to determine whether surplus water is available to certain Project lands that are not covered by long-term water supply contracts. In many cases, these lands have been receiving surplus Project water from the Reclamation for over 50 years. For numerous reasons, these lands were never covered by long-term water supply contracts. Concurrently, irrigation districts within the Project are also authorized to sell certain amounts of surplus water, subject to availability. Prior to 2001, the irrigable acreage served by temporary water contracts ranged up to 8,700 acres in some years. From 2001 through 2011, the acreage ranged from 1,250 to 2,850 acres with an annual average of 1,950 acres. USFWS has purchased approximately 3,500 of the 8,700 acres historically served by temporary water contracts, which are now located within Lower Klamath NWR (LKNWR). Surplus Project water is delivered to these lands through the existing irrigation systems, which may be operated by irrigation districts, pursuant to contracts with Reclamation.

1.3.6. Klamath Project - Power Contracts

In 1917, the U.S. entered into a contract with California Oregon Power Company (Copco) for the construction and operation of the Link River Dam, at the outlet of UKL. Pursuant to the 1917 contract, the U.S. holds title to the Link River Dam As a result of the Federal Energy Regulatory Commission's (FERC) "Project 2082", concerning Copco's construction and operation of the dams downstream from the Klamath Project, the U.S. and Copco entered into a new 50-year contract in 1956. Under the 1956 contract, Copco would operate and maintain Reclamation's Link River Dam, sell power and energy to designated irrigation loads within the Project, and with some discretion by Reclamation and subject to Project demands, set and maintain the level of UKL and Klamath River flows in order to enhance downstream power benefits at Copco hydroelectric facilities.

From 1921 until the 1997, Copco (now PacifiCorp) controlled UKL elevations and Klamath River flows downstream for those stated purposes until Reclamation began to exercise more control to meet Project water needs in light of its obligations under the ESA and for tribal trust species. This resulted in restrictions on PacifiCorp's' operational flexibility. In 1997, a Letter Agreement was signed amending the 1956 contract and allowed PacifiCorp to continue to be responsible for the daily operations and maintenance procedures at Link River Dam and to provide power to irrigation loads, but turned over to Reclamation discretionary responsibility for specifying Klamath River flows and UKL elevations through Link River Dam, as it is Reclamation's only point of control for Klamath River flows.

Reclamation and PacifiCorp entered into a subsequent Letter Agreement in 2008. Currently, PacifiCorps February 16, 2012 "Habitat Conservation Plan" and subsequent "Incidental Take Statement" also require PacifiCorp to operate Iron Gate Dam (IGD), located 63 miles below Link River Dam, in accordance with any required flow releases identified in the BO resulting from Reclamation's current or future section 7 consultations.

1.3.7. National Wildlife Refuges

The Upper Klamath, Lower Klamath, Tule Lake, and Clear Lake NWRs are adjacent to or within the Project. These refuges were established by various executive orders starting in 1908. The USFWS manages the refuges under the Migratory Bird Treaty Act (codified as 16 U.S.C. §§ 703-712), National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. §§ 668dd-668ee), National Wildlife Refuge System Improvement Act (Pub. L. 105-57, 111 Stat. 1252-1260), and other laws pertaining to the NWR System.

These refuges support many fish and wildlife species and provide suitable habitat and resources for migratory birds of the Pacific Flyway. Each year, these refuges serve as an annual stopover for approximately three-quarters of the flyway waterfowl with peak concentrations of over one million birds. Portions of the refuges are also used for agricultural purposes. *See* Section 1.3.7.1., Refuge Agricultural Lands, regarding refuges agricultural lands.

The refuges either receive water from or are associated with Project facilities. The refuges have federally-reserved water right claims for the water necessary to satisfy the refuges primary purposes subject to the Project water right and priority system. Certain refuge lands also are covered by claims pending in the Klamath Basin General Stream Adjudication for a share of the Project 1905 water right. Specific refuge lands residing within irrigation districts (i.e., federal lease and cooperative farming lands), have a priority right to water when irrigating agricultural crops. Reclamation can provide available return flows of Project water for beneficial reuse by the refuges to the extent of historic deliveries and consistent with Project purposes and available water supply.

1.3.7.1. Refuge Agricultural Lands

Reclamation annually leases approximately 20,000 acres of agricultural lands leased on an annual basis within the Lower Klamath and Tule Lake NWRs for agricultural purposes. These lands were ceded in 1905 by the states of Oregon and California to the U.S. for purposes associated with the Project. Both the Tule Lake lease lands and the Lower Klamath lease lands were originally intended to be homesteaded.

All lands within the refuges are under the jurisdiction of USFWS. Reclamation manages leases on refuge lands for agricultural purposes through a cooperative agreement. A Cooperative Agreement between Reclamation and USFWS (Contract No. 7-07-20-W0089, signed Aug. 2, 1977, sets out the responsibilities of each agency with respect to managing of water and lands within the Tule Lake, Lower Klamath Lake, and Clear Lake refuges. Reclamation also owns certain irrigation infrastructure within the refuges, which is operated and maintained in accordance with a contract with TID.

Leasing of these lands dates back to around the 1920s. In the early 1960s, Congress debated the best manner of using lands within the NWRs, and specifically, whether to dedicate the land to homesteading or to waterfowl production. Congress finally settled the matter in 1964, with passage of the Kuchel Act (Pub. L. 88-567, 78 Stat. 850). The Kuchel Act stabilized ownership by retaining the balance of the refuge lands in public ownership and making them permanently part of the refuges, subject to continued agricultural leasing of certain specified lands and where consistent with proper waterfowl management. The major components of the Kuchel Act are:

Sec. 1:
"It is hereby declared to be the policy of the Congress to stabilize the ownership of the land in the Klamath federal reclamation project, Oregon and California, as well as the administration and management of the [land within the Klamath Basin Refuges] to preserve intact the necessary existing habitat for migratory waterfowl in this vital area of the Pacific flyway, and to prevent depredations of migratory waterfowl on agricultural crops in the Pacific Coast States."

Sec. 2:
"*Such [leased] lands shall be administered by the Secretary of Interior for the major purpose of waterfowl management, but with full consideration to optimum agricultural use that is consistent*

therewith, and shall not be open to homestead entry."

Sec. 3:
"25 per centum of the net lease revenues collected during each fiscal year from [Federal Lease Lands within Lower Klamath and Tule Lake NWRs] shall be paid annually…to the counties in which such refuges are located."

Sec. 4:
"The Secretary shall, consistent with proper waterfowl management, continue the present pattern of leasing the reserved lands…within the Executive Order boundaries of the Lower Klamath and Tule Lake NWRs...as shown in…report dated April 1956. Leases for these lands shall be at a price or prices designed to obtain the maximum lease revenues. The leases shall provide for the growing of grain, forage, and soil building crops, except that not more than 25 per centum of the total leased area may be planted to row crops. All other reserved public lands included in Section 2 of this Act shall continue to be managed by the Secretary for waterfowl purposes, including the growing of agricultural crops by direct planting and sharecrop agreements with local cooperators where necessary. (78 Stat. 851; 16 U.S.C. § 695n) "

1.3.7.2. Tule Lake

Drainage of historic Tule Lake began with the construction of Clear Lake Dam in 1910 and the Lost River Diversion Dam in 1912[2]. The reclaimed lands were to be opened for homesteading. As drainage of Tule Lake was gradual, each year more land became suitable for agricultural purposes and subsequent reclamation. The reclamation process included: drainage of water, construction of irrigation facilities, and preparation of land for farming. During the construction period, reclaimed lands were to be leased to local growers by competitive bidding before opening them to homesteading.

Upon Project authorization, all lands beneath Tule Lake were scheduled for reclamation. Due to the abundance of waterfowl within the area, in 1928 President Coolidge created Tule Lake Bird Refuge (now Tule Lake NWR) by Executive Order 4975 in (Oct. 4, 1928). In 1932, to protect developed homestead lands from flooding, areas within the refuge were designated as sumps and reserved for flood control and drainage. These sumps are configured to function as evaporation ponds for the disposal of waste and drainage waters from surrounding irrigated lands, as well as the winter flows of the Lost River that cannot be diverted to the Klamath River. Areas outside the sumps, but within the refuge boundary, are leased by Reclamation for agricultural use and, if necessary, additional flood control. In addition to flood control, the sump areas provide wetland habitat for wildlife and are specifically reserved under the Kuchel Act.

1.3.7.2.1. Tule Lake Sumps

Starting in 1912, after construction of Lost River Diversion Dam and Channel, Reclamation began diverting water from the Lost River watershed to the Klamath River. During the irrigation season, a privately owned structure, Harpold Dam, is temporarily installed in the Lost River

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[2] The Lost River Diversion Dam is also known as the Wilson Dam, but will be referred to as Lost River Diversion Dam in this document.

approximately 10 miles upstream of the Lost River Diversion Dam. When Harpold Dam is installed, all the flows of the Lost River are stored behind Harpold Dam, except for approximately 15 cubic feet per second (cfs) of water, when available, that the dam is set to bypass. The remainder of the water in the Lost River below Harpold Dam is comprised of irrigation return flows originating from UKL diversions. This irrigation return/drainage flow then travels through Wilson Reservoir and into the LRDC where it can be diverted through Station 48 into the Lost River below Lost River Diversion Dam. Water released at Station 48 is comprised mostly of water released from Link River Dam into the Klamath River and diverted through the LRDC. Additional return flows into the Lost River below Station 48 are also received through private lands utilizing water from UKL.

Downstream, at the Anderson Rose Dam, these flows can be diverted into the J Canal, for irrigation of lands within TID. Anderson Rose Dam and the J Canal are both operated and maintained by the TID. Return flows from TID operations collect into a series of drains and are then lifted into the Tule Lake sumps (1A and 1B) through a series of 13 pumps. Some of the water that collects in the sumps is used to irrigation surrounding lands. Pursuant to a 1956 contract with Reclamation and associated regulations, TID operates and maintains the Tule Lake sumps and the irrigation facilities for the surrounding lease lands.

The Cooperative Agreement between Reclamation and USFWS includes reference to the Tule Lake Refuge. Specifically, section 1.B. states that: “The following interests in water and project works held by the Bureau are within the geographical area covered by this Cooperative Agreement:

1. Interests in water acquired and/or appropriated by the Bureau for reclamation purposes, including those referred to in the Klamath River Compact between the States of California and Oregon.

2. The following features within the boundaries of the Tule Lake [NWR]:
   a. N, P, Q, and R Canal and Lateral Systems
   b. No. 100, No.101, and No. 102 Drain Systems
   c. Sumps 1A and 1B…”

Further, under the terms of this Cooperative Agreement, “water acquired and/or appropriated by the Bureau for reclamation purposes” remains under Reclamation’s exclusive “administrative responsibility, control and direction,” to be used for Project purposes.

Accordingly, if water is physically available, Reclamation may divert water from the Klamath River for irrigating Project lands, including lands within TID, as well as, maintaining sump levels, in order to facilitate this irrigation. Maintaining sump levels for purposes other than irrigation would not be in accord with Reclamation’s claimed water right, which is primarily for irrigation purposes. Maintenance of the open water areas within the refuge for wildlife is supported by USFWS’ federal reserved water right, but this right is junior to the 1905 Project water right for irrigation. Thus, to the extent that TID is obtaining its irrigation water and drainage benefits under its 1956 contract with Reclamation, the sump levels may be maintained to support the open water areas of the sumps for water fowl purposes. However, if Project water is not available for delivery to TID for irrigation purposes pursuant to its contract with the U.S., no water would be available to fill or maintain open water areas in Sumps 1A and 1B. However, available return flows may reach the sumps.

Practical and physical considerations must also be taken into account when considering delivery of water to Sumps 1A and 1B. Presumably, water in the Lost River could flow through Anderson Rose Dam to the sumps; however, no physical controls exist to ensure that any water released into the system specifically for delivery to the sumps would actually reach the sumps. The Lost River flows through multiple farms with dozens of private diversions both above and below Lost River Diversion and Anderson Rose dams. When water elevations in the sumps need to be lowered, TID operates Pumping Plant D to move water from the sumps to Lower Klamath Lake and the Klamath River, via the P Canal System and the Klamath Straits Drain, respectively. USFWS receives a portion of the water supply for the Lower Klamath Lake NWR from the P Canal System, after it is pumped from the Tule Lake area through Pumping Plant D.

1.3.7.3. Lower Klamath Lake

Subsequent to the authorization of the Project, but prior to the reclamation of Lower Klamath Lake, President Theodore Roosevelt created the Klamath Lake Reservation (now called Lower Klamath National Wildlife Refuge, or LKNWR) by Executive Order 924 (Aug. 8, 1908). This order created the first refuge for waterfowl in the country, encompassing an area within California and Oregon.

Lower Klamath Lake was later hydrologically separated from the Klamath River by construction of a railroad embankment forming a levee along the west side of the lake. The levee was completed in 1912 and the gates constructed at the lake's former outlet, Klamath Straits, were closed in 1917. Except for 6,600 acres, the lakebed lands in Oregon were conveyed by the State to private parties. These lands were included in the boundaries of the newly formed KDD. In 1921, Reclamation and KDD entered a contract for the provision of Project water supply for all the lands (public and private) within the district.

Pasture grasses naturally grew on the uncovered portion of the lake bed and were subsequently grazed by adjacent landowners and others. In 1929, most of the reclaimed lands previously underlying Lower Klamath Lake were leased by Reclamation for grazing use. In 1934, the 6,600 acres of public land in Oregon (now the Klamath Straits unit or Area K) were leased as a separate grazing unit, while most of the refuge lands in California were managed directly for waterfowl use. Area K lands were conducive to producing grain and hay and have since been managed as a part of the federal lease land program as directed by the Kuchel Act.

1.3.8. Endangered Species Act

Under the ESA, federal agencies have an obligation to insure that any discretionary action it authorizes, funds, or carries out, with few exceptions, is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify its critical habitat (for exceptions, *see* 16 U.S.C. 1536(a)(2); 50 C.F.R. § 402.03). Reclamation has prepared this BA, pursuant to this requirement.

A discretionary agency action jeopardizes the continued existence of a species if it "reasonably would be expected, directly or indirectly, to reduce appreciably the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species" (50 C.F.R. § 402.02). If USFWS or NMFS determines the action is likely to jeopardize the continued existence of a listed species or likely to result in the destruction or adverse modification of critical habitat, the Services may identify reasonable and prudent alternatives. Reasonable and prudent alternatives must be consistent with the intended purpose of the action, consistent with the scope of the agency's legal authority and jurisdiction, and economically and technically feasible (50 C.F.R. § 402.02).

For the purposes of this BA, impacts to listed species are analyzed with respect to the separate actions of storage, and release or the delivery of water, and the O&M activities necessary to maintain Klamath Project facilities to ensure long-term functioning and operation.

1.3.9. Tribal Water Rights and Trust Resources

There are four federally recognized Indian Tribes in the Klamath Basin including the Klamath Tribes in Oregon (which include the Klamath, Modoc, and Yahooskin Tribes), and the Yurok Tribe, the Karuk Tribe, and the Hoopa Valley Tribe in California. Reclamation has a trust responsibility, as a federal agency, to protect tribal trust resources of three of the four federally recognized tribes. These Indian Tribes include the Klamath Tribes, the Yurok Tribe, and the Hoopa Valley Tribe.

The treaty between the United States of America and the Klamath and Modoc Tribes and Yahooskin Band of Snake Indians, Oct. 14, 1864, 16 Stat. 107 reserves to the Tribes a federal Indian reserved water right to support their hunting, fishing, and gathering rights (United States v. Adair, 723 F.2d 1394 [9th Cir. 1983], cert. denied, 464 U.S. 1252 [1984]). These rights are on lands that were formerly part of the original Klamath Indian Reservation in Oregon. The reservation abutted UKL and included several of its tributaries, notably the Williamson River.

In 1954, the Klamath Indian Reservation was terminated pursuant to the Klamath Termination Act of Aug. 13, 1954, c. 732 § 1, 68 Stat. 718 (codified at 25 U.S.C. §§ 564-564x). Under this Act, reservation lands were disposed of to private parties, individual Indians, the U.S. Forest Service, and the USFWS; however, the Tribes' hunting, fishing, and gathering rights, and supporting water rights were left intact. Although the Klamath Tribes water rights have not yet been quantified in the pending Oregon adjudication, the existence of the Klamath Tribes' rights to the water needed to protect their treaty-reserved hunting and fishing rights (with a priority date of time immemorial) and for agricultural uses has been confirmed by the Ninth Circuit Court of Appeals.

The Yurok and Hoopa Valley Tribes have federal Indian reserved fishing rights to take anadromous fish within their reservations in California. These rights were secured to the Yurok and Hoopa Indians by a series of nineteenth century executive orders. These executive orders also reserved rights to an instream flow of water sufficient to protect the Yurok and Hoopa Valley Tribes rights to take fish within their reservations. These rights vested at the latest in 1891 and perhaps as early as 1855. (*See* United States v. Adair, supra; Arizona v. California, 373 U.S. 546, 600 [1963]; United States v. Winans, 198 U.S. 371 [1905].)

1.4. Species Considered

The federally-listed species that may be affected by the Proposed Action and therefore considered in this document were identified in coordination with the appropriate regulatory agency, USFWS or NMFS. The list of species considered was generated based on letters received from USFWS and NMFS in response to Reclamation's species list requests (*See* Appendix 1B).

USFWS Jurisdiction

Reclamation submitted a memorandum to the USFWS requesting concurrence on species that may be present in the Action Area (50 C.F.R. § 402.12(c)) on September 19, 2011. The USFWS provided concurrence on October 17, 2011. The initial correspondence associated with obtaining a species list was performed in the preliminary phases of information consultation and preparation of the draft BA had just begun. As such, Reclamation verified the accuracy of the species list (50 C.F.R. 402.12(e)). The USFWS provided concurrence on November 1, 2012. (The Action Area is further defined in Part 4 and displayed in Figure 4-2).[3]

NMFS Jurisdiction

Reclamation submitted a letter to NMFS requesting concurrence on species that may be present in the Action Area (50 C.F.R. § 402.12(c)) on May 3, 2012. NMFS provided concurrence on May 10, 2012.

Table 1-1 lists the endangered and threatened species that are known to, or, are suspected to occur within the Action Area that may be affected by the Proposed Action and which are considered in this document.

Table 1-2 lists the endangered and threatened species that are known to, or, are suspected to occur within the Action Area for which Reclamation has determined that Project has no effect upon. As such, the species identified in Table 1-2 will not be discussed further in this document.

[3] The Action Area includes "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 CFR § 402.02). The Action Area extends from Upper Klamath Lake, in south central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in southern Oregon and northern California, to approximately 240 miles downstream to the outfall of the Klamath River at the Pacific Ocean, near Klamath, California.

Table 1-1. Endangered and threatened species known to or suspected to occur within the Action Area analyzed in this document.

Species	Scientific Name	Status	Critical Habitat Status
Southern Oregon/Northern California Coastal coho salmon	*Oncorhynchus kisutch*	Threatened	Designated
Lost River sucker	*Deltistes luxatus*	Endangered	Proposed[1]
Shortnose sucker	*Chasmistes brevirostris*	Endangered	Proposed[1]
Southern Resident Distinct Population Segment (DPS) killer whale	*Orcinus orca*	Endangered	Designated[2]
Southern DPS North American green sturgeon	*Acipenser medirostris*	Threatened	Designated[2]
Southern DPS Pacific eulachon	*Thaleichthys Pacificus*	Threatened	Designated

[1] The USFWS anticipates that critical habitat will be finalized in December 2012.

[2] The critical habitat designated for this species does not occur within the Action Area and is not included as a component of the current consultation.

Table 1-2. Endangered, threatened, and candidate species known to or suspected to occur within the Action Area NOT analyzed in this document.

Species	Scientific Name	Status	Critical Habitat Status
Bull trout[1]	*Salvelinus confluentus*	Threatened	Designated
Applegate's milk-vetch[2]	*Astragalus appegatei*	Endangered	None
Oregon Spotted Frog[3]	*Rana pretiosa*	Candidate	None

[1] Bull trout are not currently known to occur to occur in the Action Area and therefore is not likely to be affected by the Proposed Action.

[2] Applegate's milk-vetch is known to occur within the Action Area. However, Reclamation has determined that Applegate's milk-vetch is not likely to be affected by the Proposed Action.

[3] Oregon Spotted Frog is a candidate species that is being considered for listing.

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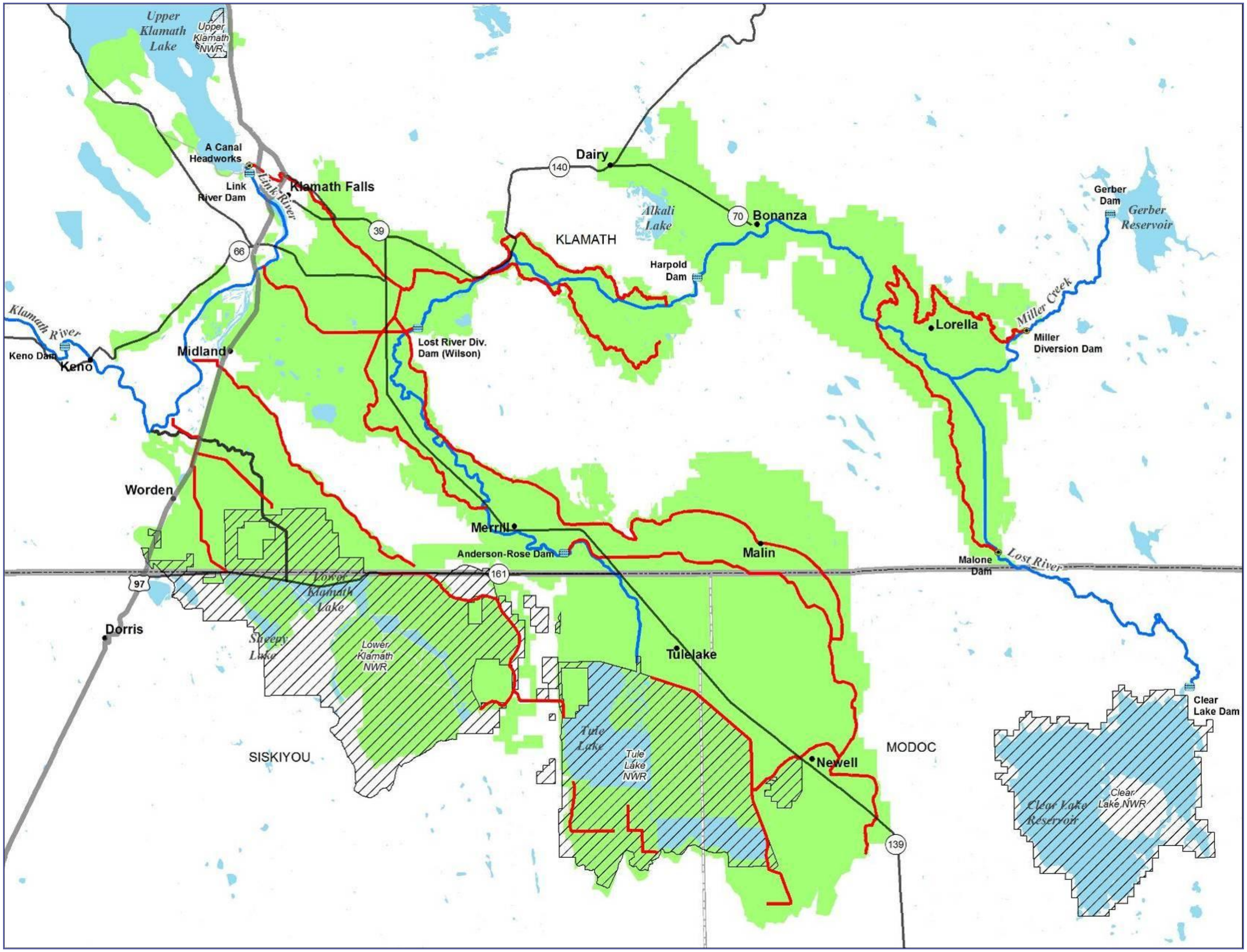

Figure 1-1. Overview map within the boundaries of the Klamath Project.

Part 2 CONSULTATION HISTORY

USFWS listed the Lost River and shortnose suckers as endangered on July 18, 1988. Reclamation began consultations the next year on the effects of aquatic herbicide use within the Project on these species. On August 14, 1991, Reclamation completed the first consultation on the effects of Project operations on all federally-listed species. On January 6, 1992, Reclamation finished another consultation, specific to Lost River and shortnose suckers. Additional consultations have occurred since then, the most recent being in 2008 (Table 2-1).

On May 6, 1997, NMFS listed the Southern Oregon/Northern California Coastal (SONCC) coho salmon Evolutionarily Significant Unit (ESU) as threatened. NMFS designated critical habitat for the SONCC Coho population on May 5, 1999. On March 9, 1999, Reclamation requested formal section 7 consultation under the ESA on the effects of its Project operations on SONCC coho salmon. On July 12, 1999, NMFS issued a final BO (effective through March 2000) which concluded that the proposed one-year operation of the Project was not likely to jeopardize the continued existence of SONCC coho salmon or adversely modify designated critical habitat. Since 1999, NMFS and Reclamation have conducted four section 7 consultations regarding the potential effects of Reclamation's proposed Project operations on SONCC coho salmon and its designated critical habitat (1999, 2001, 2002, and 2010). In 2001 and early 2002, a series of consultations were completed with NMFS and USFWS, which resulted in the curtailment of Project deliveries in 2001. In May 2002, consultations with the Services covering Project operations into 2012 were completed.

In October 2007, Reclamation initiated a consultation with both NMFS and USFWS, related to Project operations between 2008 and 2018. On April 2, 2008, USFWS issued a final BO addressing Project Operations through 2018. USFWS' 2008 BO concluded that the Project was not likely to jeopardize the continued existence of the endangered suckers or to adversely modify their critical habitat. On March 15, 2010, NMFS issued a final BO, covering the time period 2010 – 2018, which concluded Reclamation's Proposed Action was likely to jeopardize the continued existence of SONCC coho salmon and likely to result in the destruction or adverse modification of its designated critical habitat.

This BA is part of a new coordinated consultation that has been undertaken between Reclamation, USFWS, and NMFS concerning the potential effects of Project operations on ESA-listed species based on an adjusted proposal for continued operations of the Project and new scientific information related to the effects of Project operations on listed species. The table below summarizes multiple consultations undertaken by Reclamation since the listing of the suckers in 1988. During the informal consultation process related to the development of this BA, a team of federal managers was convened and termed the Agency Coordination Team (ACT). The ACT consisted of a Hydrology Team, a Biology Team, the managers for each agency, and various policy and support staff.

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
6/14/1989 (superseded by 1995 Biological Opinion (BO)	X		BO responding to the May 5, 1989, request for formal consultation pursuant to section 7 of the Endangered Species Act (ESA) regarding the use of the aquatic herbicide Acrolein (trade name Magnacide H) in canals and drainage ditches within the Klamath Project (Project) service area of Oregon and California.	The continued use of Acrolein in Project canals and drainage ditches as traditionally applied is likely to jeopardize the continued existence of the shortnose and Lost River suckers.	Shortnose and Lost River suckers
8/14/1991 (superseded by 2008 BO)	X		BO prepared in response to the February 25, 1991, request for formal consultation on the effects of the 1991 Project operations on the Lost River and shortnose suckers, bald eagle, and American Peregrine falcon.	The proposed 1991 drought operation of the Project, is likely to jeopardize the continued existence of the Lost River and shortnose suckers, and will not jeopardize the continued existence of the bald eagle or American Peregrine falcon.	Shortnose and Lost River suckers, bald eagle, American Peregrine falcon
1/6/1992 (superseded by 2008 BO)	X		BO was prepared in response to the November 15, 1991, request for formal consultation on Reclamation's proposed 1992 operation of the Project.	Likely to jeopardize shortnose and Lost River suckers. Not likely to jeopardize bald eagles or Peregrine falcons.	Shortnose and Lost River suckers, bald eagle, American Peregrine falcon
3/27/1992 (superseded by 2008 BO)	X		BO in response to the February 21, 1992, memorandum requesting reinitiation of formal consultation on the effects of the 1992 Project operations.	The proposed 1992 Project operations are likely to jeopardize sucker species; not likely to jeopardize bald eagles; no effect Peregrine falcons.	Shortnose and Lost River suckers, bald eagle, American Peregrine falcon

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
5/1/1992 (superseded by 2008 BO)	X		BO prepared in response to the April 9, 1992, memorandum requesting reinitiation of formal consultation on the effect of the 1992 Project operations at Clear Lake Reservoir.	Operation of the Project at Clear Lake Reservoir is likely to jeopardize the continued existence of the Lost River and shortnose suckers; not likely to jeopardize bald eagles; no effect Peregrine falcons.	Shortnose and Lost River suckers, bald eagle, American Peregrine falcon
7/22/1992 (superseded by 2008 BO)	X		BO dated June II, 1991, on the effects of the long-term operation of the Project on the Lost River and shortnose suckers and bald eagle.	Likely to jeopardize Lost River and shortnose suckers; not likely to jeopardize bald eagles.	Shortnose and Lost River suckers, bald eagle
2/22/1993 (superseded by 2008 BO)	X		BO on the Long-Term Operation of the Project - UKL operations.	One-year modification of required lake elevation 4,141 feet on March 1, 1993	Shortnose and Lost River suckers
8/11/1994 (superseded by 2008 BO)	X		BO in response to the memorandum of January 20, 1994, requesting reinitiation of formal consultation on the effects of the long-term operation of Reclamation's Project, specifically referring to new information at Clear Lake Reservoir.	Operate Clear Lake Reservoir to assure a new minimum surface elevation of 4,521 feet on October 1 of each year.	Shortnose and Lost River suckers, bald eagle
2/9/1995	X		Final BO on the use of Pesticides and Fertilizers on Federal Lease Lands and Acrolein and Herbicide Use on the Project Rights-of-way located on the Project. Reinitiation of consultation on the use of Acrolein for aquatic weed control in Reclamation canals and drains).	Is not likely to jeopardize the continued existence of the Lost River and shortnose suckers. Not likely to affect bald eagle, American Peregrine falcon, or Applegate's milk-vetch.	Shortnose and Lost River suckers, bald eagle, American Peregrine falcon Applegate's milk-vetch

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
2/2/1996 (not superseded by 2008 BO)	X		BO prepared for reinitiation of Formal Consultation on the Use of Pesticides and Fertilizers on Federal Lease Lands and Acrolein and Herbicide Use on the Project Rights-of-Way Located on the Klamath Project.	Use of Metam-Sodium, Lorsban, Pounce, and Disyston on Project lands as described under the Description of the Proposed Action is not likely to jeopardize the continued existence of the bald eagle, American Peregrine falcon, and Lost River and shortnose suckers.	Shortnose and Lost River suckers, bald eagle, American Peregrine falcon
7/15/1996 (superseded by 2008 BO)	X		BO prepared in regards to PacifiCorp and The New Earth Company operations, as permitted by Reclamation under the Project.	Not likely to jeopardize the continued existence of the Lost River and short nose suckers, or modify proposed critical habitat.	Shortnose and Lost River suckers
4/2/1998 (superseded by 2008 BO)	X		Amendments to the July 22, 1992, BO on the effects of the long-term operation of the Project on the Lost River and shortnose suckers, bald eagle, and American Peregrine falcon.	Extend the date for completion of A Canal screen until 2002.	Shortnose and Lost River suckers
4/20/1998	X		Amendments to the 1992 BO for Agency Lake Ranch impoundment operations.	Not likely to jeopardize affected species.	Shortnose and Lost River suckers
4/21/1998 (superseded by 2008 BO)	X		Amendments to the August 27, 1996, BO, consultation on PacifiCorp and The New Earth Company operations, as permitted by Reclamation under the Project.	Three amendments involving reporting, placing debris reduction screens, and effectiveness monitoring.	Shortnose and Lost River suckers
6/2/1998		X	BA on Project Operations, requesting formal consultation.	NMFS deferred consultation until the following year.	N/A

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
7/13/1998 (superseded by 2008 BO)	X		An amendment to the revised July 22, 1992, Project long term operations BO, dealing with Anderson-Rose releases. The purpose of this amendment is to adjust requirements for release of spawning flows from Anderson-Rose Dam on the Lost River.	USFWS concurs with Reclamation's recommended Reasonable and Prudent Alternative (RPA) changes.	Shortnose and Lost River suckers
3/9/1999		X	Draft Project Annual Operation Plan Environmental Assessment (EA); modified operation period between April 1999 and March 2000.	Recommended Interim Flows.	SONCC coho salmon
4/15/1999	X		An amendment to the 1996 BO to address lowered water levels in UKL to reduce risk of flooding in Spring 1999	Will be included in Final BA.	Shortnose and Lost River suckers bald eagle
6/18/1999		X	Requested formal consultation, involving Project Annual Operation Plan EA; modified operation period between April 1999 and March 2000.	Requested formal consultation.	SONCC coho salmon
7/12/1999		X	NMFS BO on Project operations through March 2000.	Not likely to jeopardize affected species or adversely modify designated critical habitat.	SONCC coho salmon
8/18/1999	X		BO in regards to the Project - One-year, emergency amendment to the 1995 BO, USFWS # 1-7-95-F-26: Use of Pesticides and Fertilizers on Leased Lands and Use of Acrolein in Project Canals and Drains.	By following a set of terms and conditions (as outlined within the document) the Project will be exempt from the prohibitions of ESA Section 9.	Shortnose and Lost River suckers
9/10/1999 (superseded by 2008 BO)	X		Revised amendment to the 1992 BO to cover operations and maintenance of Agency Lake Ranch impoundment.	Not likely to jeopardize the affected species.	Shortnose and Lost River suckers

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
4/4/2000		X	NMFS letter regarding BO & Incidental Take Statement; advised Reclamation should request consultation on Project operations.	1999 BO and Incidental Take Statement expired.	SONCC coho salmon
4/26/2000		X	Reclamation letter acknowledged receipt of NMFS letter regarding Klamath River Flows Below IGD - 2000 Operation Plan-Klamath Project.	Determined proposed flows were sufficient and necessary to avoid 7(d) foreclosures and fulfill obligation to protect tribal trust resources.	SONCC coho salmon
1/22/2001		X	Reclamation's BA of the Project's continuing operations on SONCC ESU coho salmon and critical habitat for SONCC ESU coho salmon.	Detailed proposed operations into the future.	SONCC coho salmon
4/5/2001	X		Reinitiation of formal consultation on long-term operations of the Klamath Project: a one year consultation requested by Reclamation	Will be included in Final BA.	Shortnose and Lost River suckers
4/6/2001		X	NMFS 2001 BO on Project operations.	Likely to jeopardize SONCC and likely to adversely modify designated critical habitat.	SONCC coho salmon
4/13/2001 (superseded by 2008 BO)	X		Concurrence memorandum responding to Reclamation's request to postpone spawning releases at Anderson Rose Dam for 2001.	Not likely to jeopardize sucker species; USFWS concurred with drought year assessment.	Shortnose and Lost River suckers
8/22/2001 (superseded by 2008 BO)	X		Amendment to 4/5/2001 BO on Project operations to cover safety of modification of Clear Lake Dam.	Not likely to jeopardize affected species.	Shortnose and Lost River suckers, bald eagle

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
9/12/2001 (superseded by 2008 BO)	X		BO amending the April 5, 2001 BO on Project operations to cover Link River Topographic Survey Fish Passage Assessment.	Not likely to jeopardize the continued existence of the Lost River and Shortnose suckers and will not likely modify their proposed critical habitat.	Shortnose and Lost River suckers
9/19/2001	X		BO amending the November 27, 2000 BO for the airport runway extension project and the April 5, 2001 BO on Project operations to cover salvage in Lost River Diversion Canal and for the Station 48 maintenance project.	Not likely to jeopardize the continued existence of the Lost River and Shortnose suckers and will not likely modify their proposed critical habitat.	Shortnose and Lost River suckers
9/28/2001		X	Amendment to the April 6, 2001 BO and Reasonable and Prudent Alternative (RPA) for Reclamation's Project operations.	Provided flows for Oct - Dec 2001.	SONCC coho salmon
12/28/2001		X	NMFS BO amendment, RPA for Reclamation's Project operations.	Provided flows for Jan - Feb 2002.	SONCC coho salmon
2/27/2002	X	X	Reclamation's final BA on effects of proposed actions related to Klamath Project operations between April 1, 2002 and March 31, 2012.	Requested initiation of formal ESA section 7 consultation.	SONCC coho salmon, Shortnose and Lost River suckers
3/28/2002 (superseded by 2008 BO)	X		Biological/Conference Opinion Regarding the Effects of Operation of Reclamation's Klamath Project During the Period April 1, 2002, through May 31, 2002 on the Endangered Lost River and Shortnose Suckers, Threatened bald eagle, and Proposed Critical Habitat for the Lost River/Shortnose Suckers.	Not likely to jeopardize affected species; Concurred with "not likely to adversely affect" determination.	Shortnose and Lost River suckers, bald eagle

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
5/16/2002		X	NMFS draft BO on Klamath Project operations between April 1, 2002, and March 31, 2012.	Likely to jeopardize SONCC coho salmon.	SONCC coho salmon
5/31/2002		X	NMFS BO on Project operations.	Jeopardy Opinion.	SONCC coho salmon
5/31/2002 (superseded by 2008 BO)	X		Biological/Conference Opinion Regarding the Effects of Operation of Reclamation's Klamath Project During the Period June 1, 2002, through March 31, 2012 on the Endangered Lost River and Shortnose Suckers	Not likely to jeopardize the continued existence of Lost River and shortnose suckers [Will confirm in Final BA].	Shortnose and Lost River suckers
7/24/2002 (not superseded by 2008 BO)	X		BO and Conference Report for Construction of the A Canal Fish Screen and the Link River Fish Ladder, Klamath County, Oregon.	Not likely to jeopardize the continued existence of shortnose and Lost River suckers.	Shortnose and Lost River suckers, bald eagle
3/4/2003 (superseded by 2008 BO)	X		Amendment to the 2002 BO on the Effects of the 10-Year Operations Plan for the Klamath Project as it Relates to Operation of Clear Lake and Gerber Reservoir.	No effects to Lost River and shortnose suckers different from those analyzed in the 2002 BO.	Shortnose and Lost River suckers
5/31/2007 (not superseded by 2008 BO)	X		BO Regarding the Effects on Listed Species from implementation of the pesticide use program on federal leased lands, Tule Lake and Lower Klamath NWRs, Klamath County, Oregon, and Siskiyou and Modoc counties, California.	USFWS recommends action agencies periodically conduct water, sediment, and fish tissue monitoring in Tule Lake Sump IA to ensure pesticides are at concentrations below those having an adverse effect to listed species.	Lost River and Shortnose suckers, bald eagle
4/2/2008	X		BO on the effects of Reclamation's proposed Project Operations from 2008 to 2018.	Not likely to jeopardize affected species.	Shortnose sucker, Lost River sucker

Table 2-1. Consultation History 1989 through 2010 with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS).

Date	Agency		Subject of Consultation	Determination	Affected Species/Critical Habitat
	USFWS	NMFS			
3/15/2010		X	NMFS BO on operations of the Project between 2010 and 2018.	Not likely to jeopardize eulachon or green sturgeon; likely to jeopardize SONCC coho salmon and adversely modify their designated critical habitat.	SONCC coho salmon, Pacific eulachon, Southern DPS green sturgeon

Sources: Biological Assessment. The Effects of the Proposed Action to Operate the Klamath Project from April 1, 2008 to March 31, 2018 on federally-Listed Threatened and Endangered Species. U.S. Dept. of the Interior, Bur. Reclamation. (Oct. 2007). Tables 7.1 and 7.2.

Biological/Conference Opinion Regarding the Effects of the U.S. Bureau of Reclamation's Proposed 10-Year Operation Plan (April 1, 2008 – March 31, 2018) for the Klamath Project and its Effects on the Endangered Lost River and Shortnose Suckers. April 2, 2008. Table 1-1.

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Part 3 ANALYTICAL APPROACH

3.1. Analytical Approach

Project operations have been continually adjusted to comply with ESA requirements since the early 1990s, when the first consultations (for shortnose and Lost River suckers) occurred. To improve the coordination between Reclamation and the Services, unprecedented coordination has occurred in preparation of this BA for the initiation of formal consultation with the Services. The goal of the collaborative efforts for this consultation was to develop improved and common understanding of the available information and analytical tools available, and to facilitate a continuous information sharing process. The general analytical approach used by Reclamation in the development of this BA has been framed by this collaboration and by a number of factors discussed below.

3.2. Legal, Analytical, and Ecological Framework

Pursuant to section 7(a)(2) of the ESA, federal agencies must ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The analytical framework associated with this BA is outlined below. The ecological framework within the Effects Analysis for suckers is based on lake elevations and habitat, whereas the Effects Analysis for coho salmon is based upon model outputs below IDG. Therefore, the analyses have been conducted differently and the ecological approach is detailed in Parts 7 and 8, respectively.

Section 7(a)(2) of the ESA and implementing regulations (50 C.F.R. Part 402), and associated guidance documents (e.g., Endangered Species Consultation Handbook, 1998) suggest BAs present the following:

1. A description of the action being considered (Proposed Action).

2. A description of the specific area that may be affected by the action (Action Area).

3. A description of any listed species or critical habitat that may be affected by the action.

4. A description of the manner in which the action may affect any listed species or critical habitat, and an analysis of any cumulative effects (Effects Analysis).

5. Relevant reports, including any environmental impact statements, environmental assessments, BAs, or other analyses prepared on the proposal.

6. Any other relevant studies or other information available on the action, the affected listed species, or critical habitat.

Reclamation's Klamath Project has a unique mix of factors that are considered in operational decisions, even if not directly related to a section 7 consultation, including:

Limited Carry-over Water Storage Capacity. UKL, the major Project water source, is relatively shallow and too small to capture and store large quantities of spring runoff. The Project thus lacks facilities to store water in wet years to meet all water needs in dry years.

Dependency upon Forecasted Streamflows for Water Management Decisions. As a consequence of the lack of storage in the Basin, Reclamation must base its various water management decisions each year on stream flow forecasts issued by the Natural Resources Conservation Service (NRCS) between January and June. The final forecast (generally the most accurate, but still subject to error) is released in June, approximately three months after the beginning of the irrigation season. As a result, the amount of water actually available for delivery and other purposes is uncertain and subject to change.

Multiple Legal Responsibilities. The Secretary, through Reclamation, must manage and operate the Project pursuant to various legal responsibilities, including the Reclamation Act of 1902, the Act of September 2, 1964 (Kuchel Act), ESA, and the federal trust responsibility to Indian tribes. These independent acts and mandates do not always operate in harmony with one another.

A Highly Variable Natural Hydrologic System. The Klamath Basin has demonstrated a wide range of variable water conditions, from extreme drought conditions to extreme flood flow, sometimes within the span of just a few years. Recent precipitation and stream flow trends (within the last 10 years) have been drier than the median for the Period of Record used in this analysis, but such fairly short term trends can, and have, reversed within the Basin making any long-term forecasting difficult. Reclamation believes that the Period of Record contains a reasonable range of flows likely to be experienced over the next 10 years. If the trend in recent declining flows continues, that could reduce available water for all resources in the basin, in the manner defined by the Proposed Action.

3.3. Use of Best Available Science

The ESA requires that the action agency, in any request of formal consultation, provide "the Service with the best available scientific and commercial data available, or that can be obtained during the consultation for an adequate review of the effects that an action may have upon listed species or critical habitat" (50 C.F.R. § 402.14(d)). Additionally, U.S. Department of the Interior Policy (305 Department Manual 3) states that "Scientific and scholarly information considered in Departmental decision making must be robust, of the highest quality, and the result of as rigorous scientific and scholarly processes as can be achieved."

Reclamation has prepared this BA using the best available scientific and commercial data available. Reclamation has included all references that were reviewed and/or referenced in preparation of this document.

3.4. Water Resource Integrated Modeling System

Reclamation used results generated by the Water Resource Integrated Modeling System (WRIMS model engine or WRIMS) to identify the Klamath River and UKL hydrographs that are likely to occur as a result of implementing the Proposed Action. WRIMS is a generalized water resources modeling system, broadly accepted by the hydrologic community, for evaluating operational alternatives of large, complex river basins. WRIMS integrates a simulation language for flexible operational criteria specification, a linear programming solver for efficient water management decisions, and graphics capabilities for ease of use. These combined capabilities provide a comprehensive and powerful modeling tool for water resource systems simulation. Reclamation has worked closely with the Services' hydrologists to develop a WRIMS model specific to the Klamath Basin for this consultation.

Data files generated by the WRIMS model include daily modeled output. The daily modeled outputs can be summarized by week, month, or water year. For ongoing analysis, Reclamation will also use exceedance tables created by WRIMS results. Exceedance tables are developed through data analysis of historical hydrological conditions. Exceedence tables depict the probability that specific hydrologic conditions will be met or exceeded during a given time. For example, a 95 percent exceedance value would represent relatively dry conditions, because actual hydrological conditions can be expected to meet or exceed that value in 95 out of 100 years. Conversely, a 5 percent exceedance value would represent a period of unusually high precipitation, given that conditions can only be expected to meet or exceed that value in 5 years out of 100. A 50 percent exceedance value represents average hydrological conditions. It is important to note that within a water year (i.e., October 1 to September 30) hydrologic conditions, as represented by the exceedance value, are likely to vary between and within months.

3.5. Period of Record Hydrograph

For UKL and the Projects West Side service area (excluding Tule Lake), the Hydrology Team[4] of the ACT recommended using October 1, 1980 to September 30, 2011 for the Period of Record from which to run the daily time step WRIMS model. This time period October 1, 1980 to September 30, 2011 includes recorded inflow into UKL water years along with a reasonable adequate distribution of dry, average, and wet years. With this range of data, the WRIMS model is able to evaluate a particular water operation strategy across the full range of reasonably foreseeable annual precipitation patterns. Reclamation used WRIMS in our analysis to estimate mainstem Klamath River flows at IGD and UKL elevations that would likely be realized through implementation of the Proposed Action during the Period of Record. Reclamation considers the resulting model outputs to reflect the range of flows reasonably expected to occur during the 10-year period of the Proposed Action (April 1, 2013 through March 31, 2023).

[4] Based on the Period of Record discussion paper, prepared by the Agency Coordination Team's Hydrology Team, dated November 04, 2011. The Team is made up of representatives fromthe Services and Reclamation for the purpose of this consultation.

For Project facilities on the East Side (including Clear Lake Reservoir, Gerber Reservoir, the Lost River, and Tule Lake), Reclamation identified different Periods of Record as representative for different features, depending on the quality and availability of relevant hydrologic data which was different than the Period of Record used on the West Side. In arriving at the applicable Period of Record for each feature, Reclamation examined all available hydrologic records. For Clear Lake Reservoir, Reclamation uses the Period of Record of 1902 to 2012 which included information prior to the construction of Clear Lake Dam (1910). For Gerber Reservoir, Reclamation uses the Period of Record of 1925 to 2012.

While the 31-year Period of Record used for UKL analysis purposes reflects a range of wet and dry water years, actual conditions may deviate from the representative trend, possibly due to climate change. However, there is currently a lack of reliable forecasting tools available to adequately quantify the influence of global climactic changes on local hydrologic conditions. However, a current Klamath Basin Study is evaluating climate change impacts to supply and demand in addition to developing adaptation strategies for the Basin. The Basin Study is scheduled to be completed in fall 2014.

3.6. Uncertainties and Unknowns

In any biological system, there are always unknowns and uncertainties. This fact is especially true of aquatic ecosystems. In the Klamath Basin, these uncertainties and unknowns exist for all federally-listed species. The following describes some of the key issues where uncertainties and unknowns exist:

General

1. Uncertainties exist in all models. Models are a simplification and a simulation of complex ecologic and/or hydrologic processes. All models are an approximation of actual conditions, and include assumed values, or computed values that are based upon uncertain data or information. Uncertainties associated with the WRIMS model are discussed in Appendix 4A.

2. Uncertainties exist in all measurements. For example, United States Geological Survey (USGS) gauges have some amount of error that can vary by specific gauge and flow. Estimated numbers of fish, mortality, and habitat preference contain inherent uncertainty. The analysis uses numbers for comparative purposes to determine relative effect rather than absolute values.

Suckers

1. Reasons for the loss of juvenile suckers (of both species) during their first year in UKL are unknown. This represents a “Baseline Condition” and there is no available evidence linking this loss to Project operations.

2. Suckers are entrained at Project facilities. It is unknown whether entrainment within the Project is compensatory or additive mortality to sucker populations, particularly at UKL, Clear Lake Reservoir, and Gerber Reservoir. The Baseline and analysis sections discuss entrainment and the analysis section concludes that entrainment is an adverse effect.

3. Taxonomic status of sucker species in Gerber Reservoir is uncertain. The analysis will assume that the suckers in Gerber Reservoir are federally-listed shortnose suckers.

4. The recovery of passive integrated transponders at fish-eating bird colonies in the Upper Klamath Basin indicates bird predation occurs at UKL and Clear Lake Reservoir. Factors influencing bird predation are currently unknown. This represents a Baseline condition and Reclamation has no evidence linking this mortality to Project operations.

Coho Salmon

1. Little is known about juvenile coho salmon movement into, out of, and within the mainstem of the Klamath River. The analysis for this BA assumes similar movement patterns as nearby drainages, where data is available.

2. Salmonids in the Klamath Basin are exposed to a number of pathogens and diseases that can impact all life stages. Disease effects are an uncertainty that varies annually based on water temperature, water year, and other factors. In field studies, the effects of flow and temperature are difficult to separate from those of infectious dose and mortality of fish. At this time, information is not available to determine the impacts of the Project on coho salmon mortality due to disease.

3. Uncertainty exists concerning the interrelationship of hatchery produced fish with the naturally produced coho salmon when both are present in the natural environment (i.e., after the hatchery fish are released into the Klamath River). The effects of hatchery operations are included as a Baseline Condition.

4. Marine salmon survival during ocean rearing is an uncertainty that depends on a number of interacting factors, including the abundance of prey, density of predators, the degree of intra-specific competition (including that from hatchery fish), and fisheries. The importance of these factors in turn depends on ocean conditions. Even relatively small changes in local and annual fluctuations in marine water temperatures can be related to changes in salmon survival rates. These drastic, and unpredictable, changes in annual ocean productivity are considered a Baseline condition.

While this list of uncertainties and unknowns is not exhaustive, Reclamation has coordinated with the Services to identify these uncertainties and unknowns, given our current scientific understanding.

3.7. Other Existing and Future Actions in the Action Area Not Included in the Environmental Baseline or Cumulative Effects

Representatives of 45 organizations, including federal agencies, the states of California and Oregon, Indian tribes, counties, irrigators, and conservation and fishing groups of the Klamath Basin negotiated the Klamath Basin Restoration Agreement to address the long-term needs of the Basin. Separately, many of those same organizations negotiated with PacifiCorp, which is not a party to the Klamath Basin Restoration Agreement, to arrive at the Klamath Hydroelectric Settlement Agreement. The Klamath Hydroelectric Settlement Agreement addresses the interim operations of the four PacifiCorp dams downstream of the Project and establishes a framework for their potential removal. The final outcome of this process, which still requires Congressional approval, is not certain enough to be included in the cumulative effects discussion, but is important to recognize as part of the overall context of this consultation. The interim actions defined in the Klamath Hydroelectric Settlement Agreement and the HCP are included in the Environmental Baseline used for this BA. The Klamath Basin Restoration Agreement, which is not included in this analysis, is intended to:

1. Restore and sustain natural production and provide for full participation in harvest opportunities of fish species throughout the Klamath Basin.

2. Establish reliable water and power supplies which sustain agricultural uses and communities and NWRs.

3. Contribute to the public welfare and the sustainability of all Klamath Basin communities (http://klamathriverrestoration.org/kbra-summary.html).

The only direct effect the Klamath Basin Restoration Agreement and Klamath Hydroelectric Settlement Agreement has upon this section 7consultation is to inform the decision to use a fairly short time-frame for this consultation (i.e., 10 years) based upon the expected schedule for implementation of these proposed settlement actions. This timeframe was selected based upon Section 22.1.2 of the Klamath Basin Restoration Agreement, which compels Reclamation to formally consult on Project operations consistent with the limitations on diversion of water from UKL and the Klamath River as provided for in the agreement unless the effects of such action have already been adequately considered in a biological opinion. Any such consultation would supersede the current consultation.

A similar situation exists for the on-going Klamath Basin General Stream Adjudication that Oregon is conducting. When complete, this adjudication will clarify the priority of water rights under Oregon State law and should result in a more definitive understanding of water supply availability for all uses. An Order of Determination is expected to be completed and released at the end of 2012. As such, water could be added beyond what was assumed available. This additional potential water would only be diverted by the Project if inflows assumed by the analysis had been reached. Reclamation believes this would have no effect because diversion of this water would not reduce the amount of water committed to the lake or the river. Due to the adjudication (or other water mitigation programs) supplemental water may be present in the lake. However, while the initial steps of the adjudication process are nearing completion, the process allows interested parties the right to appeal. Parties to the process expect numerous appeals to be filed, and accordingly, the Order of Determination may not be finalized for many years, if not decades. Accordingly, the final outcome is not reasonably foreseeable.

3.8. Future Potential Actions That May Occur within the Life of this Consultation Period

3.8.1. Tule Lake Refuge Sump 1A Wetland Enhancement Sump Rotation Proposal

USFWS is currently considering a wetland enhancement proposal that would consist of sump rotation to promote wetland vegetation development in Sump 1A at Tule Lake NWR.

Reclamation would continue to be responsible for water deliveries and Sump 1A elevations until such time the following requirements have been met:

- All infrastructure is in place;
- All Project contracts can be met;
- Safety and flood control considerations are met; and
- A fish transport plan is executed

Once these requirements are met, Reclamation may begin delivering water supplies to Sump 1B and maintaining elevations in Sump 1B. The elevations that provide appropriate protection of the species would be determined at that time.

3.9. Key Consultation Considerations

Reclamation has participated in extensive informal consultation with the Services in preparation of this BA. This effort has involved the dedication of many hours of staff and management time resulting in an improved working relationship among agency staff and members of the Agency Coordination Team. This collaboration has greatly improved this BA. Reclamation made efforts to provide the Services' opportunity to review drafts of the document and worked diligently to respond to the comments received. However, the final content of the BA is Reclamation's responsibility and has been prepared in compliance with section 7 of the ESA and associated implementing regulations.

The Proposed Action is modeled and the model outputs are used to define key parameters such as Project water availability, lake elevations, and Klamath River flows. The hydrologic model includes all hydrologic features of the Environmental Baseline (e.g., non-federal dams and diversion systems, etc.). The effects that result from the implementation of the Proposed Action were added to these features of the Environmental Baseline.

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Part 4 PROPOSED ACTION

4.1. Action Area

The Action Area includes "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 C.F.R. § 402.02; Figure 4-1).

The Action Area extends from UKL, in south central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in southern Oregon and northern California, to approximately 240 miles downstream to the mouth of the Klamath River at the Pacific Ocean, near Klamath, California (Figure 4-2).

Within the Upper Klamath Basin, the Action Area includes Agency Lake, UKL, Keno Reservoir (Lake Ewauna), Lost River including Miller Creek, and all Reclamation-owned facilities including reservoirs, diversion channels and dams, canals, laterals, and drains including those within Tule Lake and Lower Klamath NWR's.

Direct effects of the Proposed Action are those effects that occur as a result of implementation of the proposed project. Indirect effects are those effects that are caused by or will result from the Proposed Action and are later in time, but are still reasonably certain to occur (50 C.F.R. § 402.02). This BA considers both direct and indirect effects the same for the purposes analysis of potential species impacts.

The direct effects of Project operations extend downstream from UKL to the Klamath Straits Drain, which is the last Reclamation Project feature. The Klamath Straits Drain enters the Klamath River upstream of Keno Dam, Oregon. There is a potential for direct effects on listed suckers to occur throughout the Action Area, although measures such as fish screens built at the A-Canal and Clear Lake Dam and a ladder has been installed at the Link River Dam to minimize effects.

Effects on suckers and coho salmon continue beyond the Project through a series of hydroelectric dams and reservoirs (Keno, J.C. Boyle, Copco I, Copco II, and Iron Gate dams) owned and operated by PacifiCorp, and potentially continue to the mouth of the Klamath River at the Pacific Ocean. The effects of the Project operations diminish with increasing distance downstream as the Klamath River volume increases with water from the Scott, Shasta, Salmon and Trinity rivers, as well as numerous creeks, other tributaries, seeps, and springs. Figure 4-3 shows the flow volumes contributed to the mainstem Klamath River by these tributaries seasonally, illustrating this diminishing direct effect.

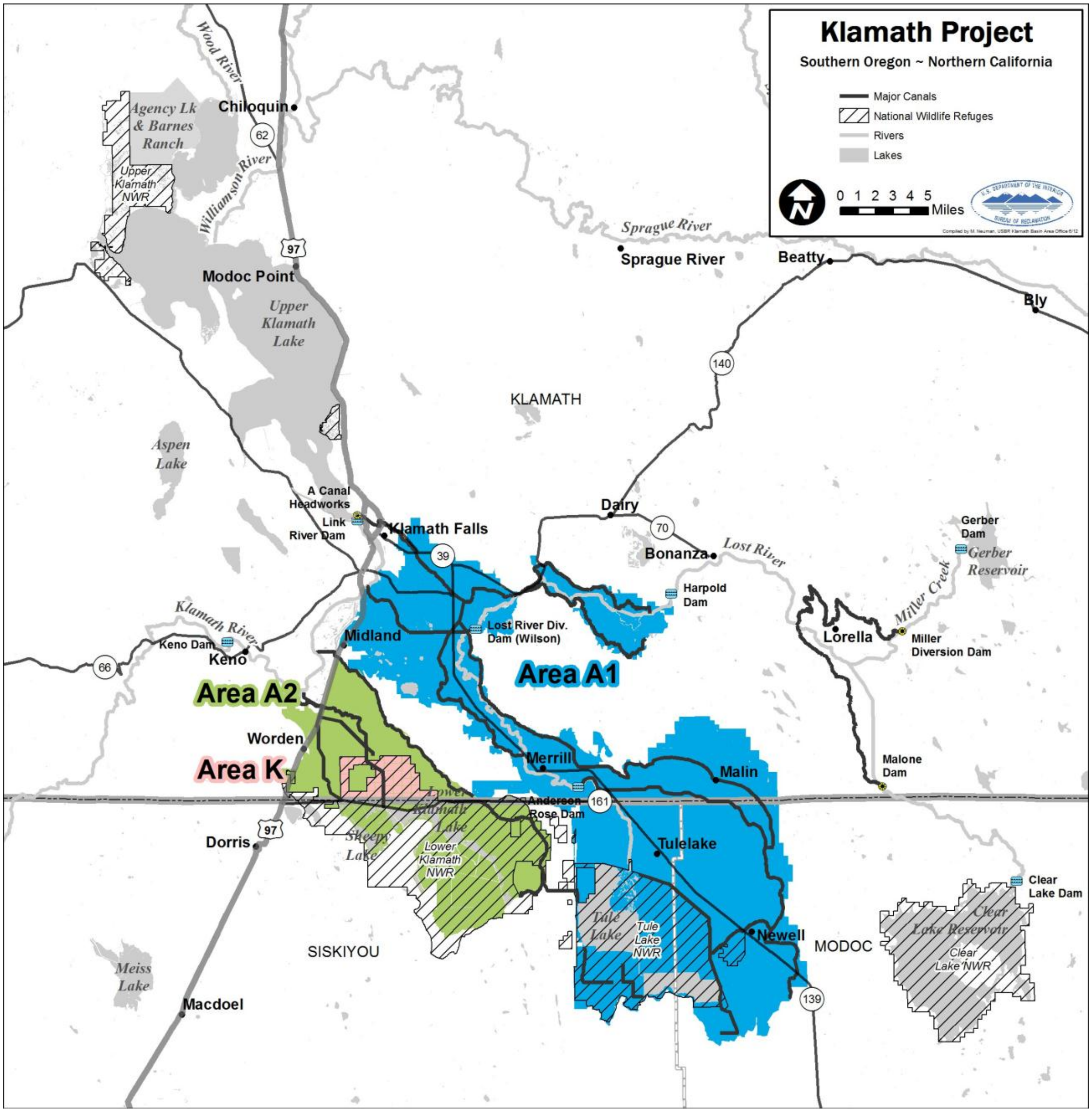

Figure 4-1. Upper Klamath Basin of Oregon and California. Klamath Project lands are shown as shaded area on the map. *Source: Bureau of Reclamation 2012.*

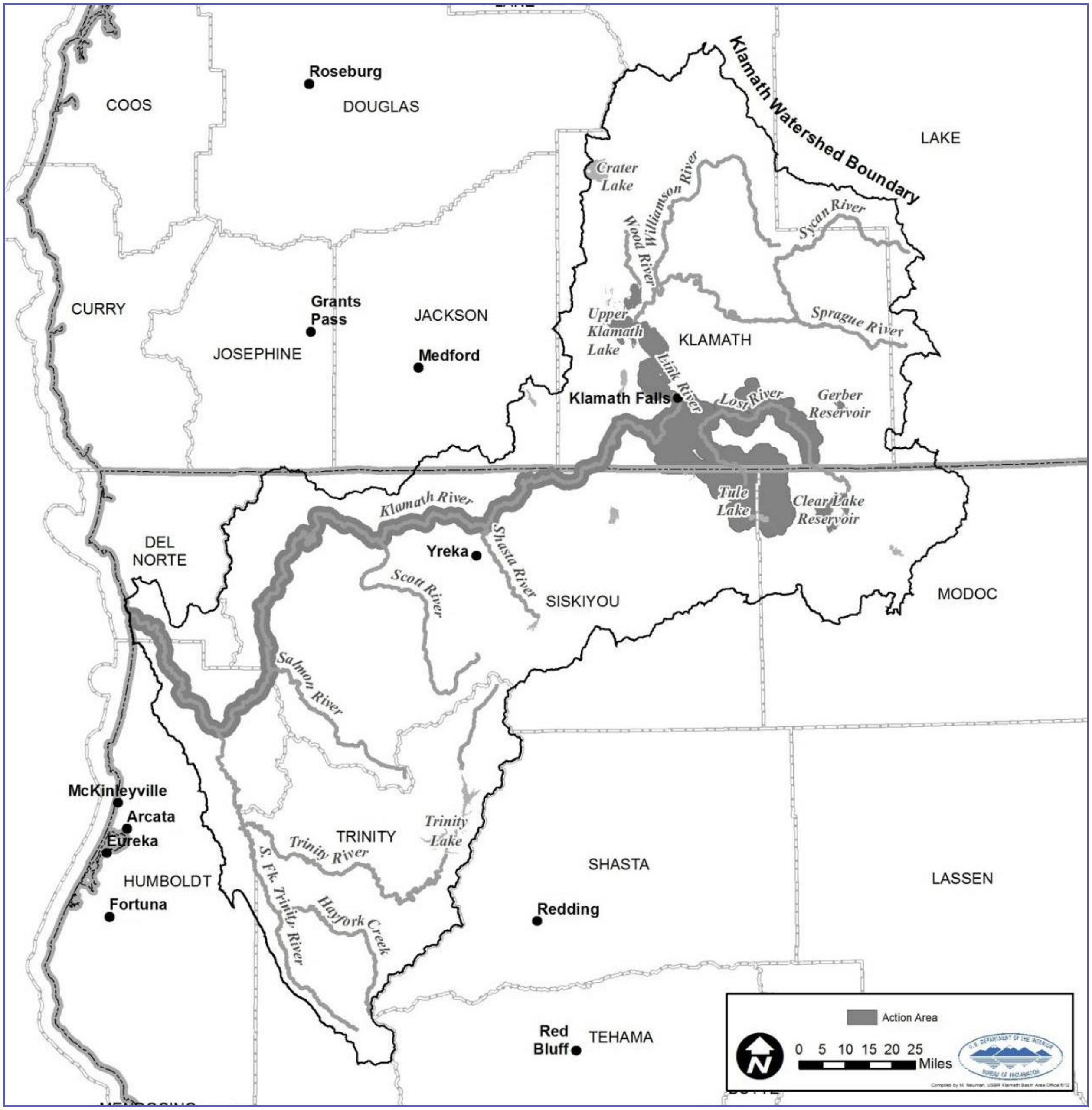

Figure 4-2. Map of the Action Area. *Source: Bureau of Reclamation 2012.*

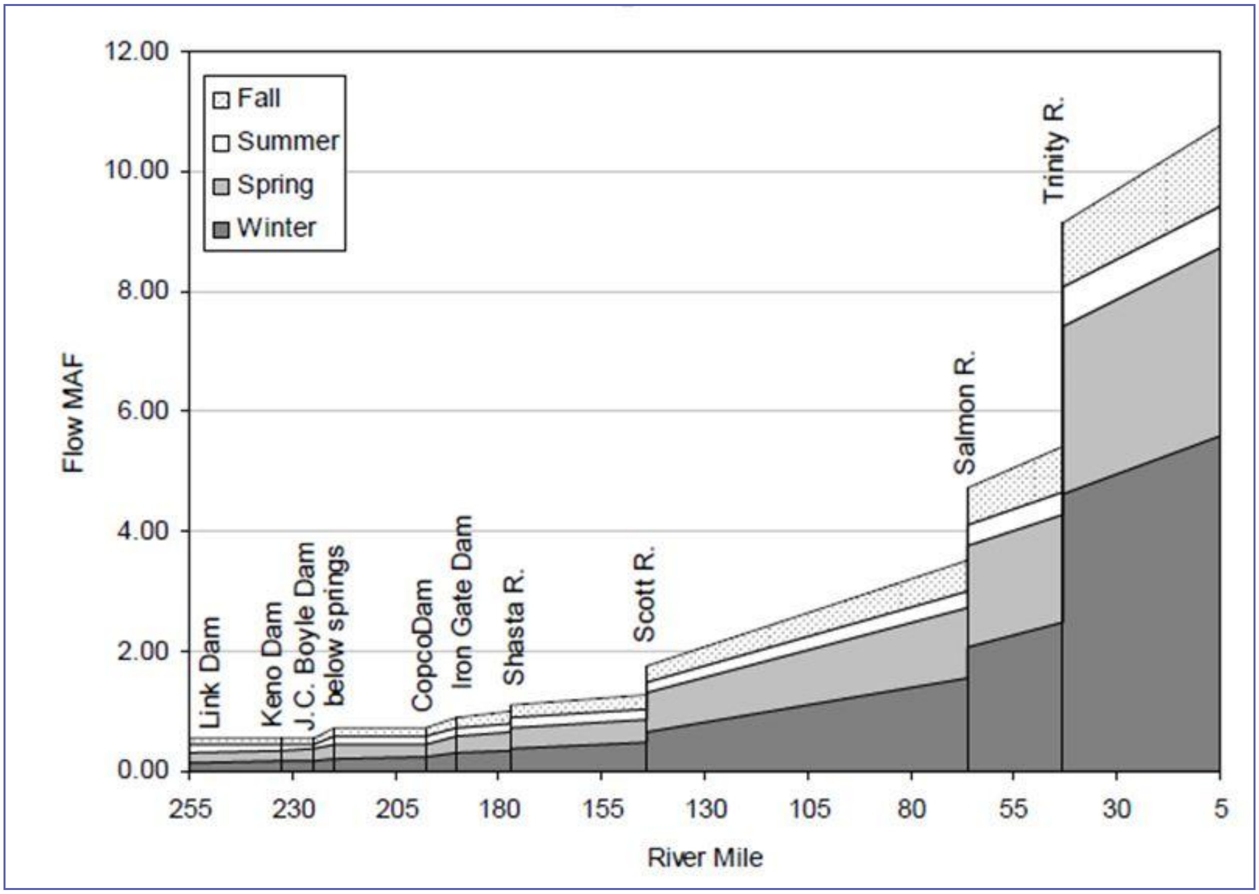

Figure 4-3. Simulated seasonal flows in the Klamath River from Link River to Turwar in 2000. *Source: Figure 14, Cramer Fish Sciences 2007.*

4.2. Background

Minimum UKL elevations (since 1991) and Klamath River flows (since 2001) out of IGD have been prescribed through a series of BOs from the Services. Reclamation, USFWS, and NMFS recognize that past proposed actions and BOs have not provided the full range of flexibility and benefits for listed species, NWRs or Project irrigators that is needed in order to effectively manage the Klamath River system. In recognition of these competing needs of UKL, the Klamath River, NWRs, and the Project, Reclamation has formulated a methodology for a Proposed Action for 2013 to 2023 to maximize the certainty and quantity of irrigation and refuge deliveries while meeting its regulatory requirement to avoid jeopardy to ESA-listed species and adversely modifying or destroying designated critical habitats.

In the October 2007 BA, Reclamation used historical hydrologic data and NRCS net UKL inflow forecasts (April through September) from 1961 to 2006 to represent the range of expected water supply conditions for the 2008 to 2018 consultation. Subsequently, NRCS reconstructed their historical forecasts back to the spring of 1981, based upon improved algorithms and updated historical data. In the current consultation, Reclamation, USFWS, and NMFS agreed to use the 1981 through 2011 historical hydrology and revised NRCS forecasts for UKL net inflows as the most complete set of data available for development of the Proposed Action. This 31-year

Period of Record also includes a broad range of hydrologic conditions that likely covers the range of future conditions within the 10-year timeframe covered by the Proposed Action.

Since the Williamson River is the main tributary to UKL, flows for the Williamson River were assessed for the 1981 through 2011 period to provide additional insight on the representativeness of UKL net inflow hydrology for the 1981 through 2011 period. Dividing annual cumulative Williamson River flows from 1918 to 2011 into 10 groups of 10 percentiles, showed at least one year of UKL net inflows from 1981 through 2011 was in each group of values and the 31 years included the two lowest flow years on record. Analysis of monthly values showed a similar wide distribution of values, with the caveat that summer months (July through August) were noticeably drier from 1981 through 2011 than from 1918 to 2011 as a whole. This provides increased confidence that the 1981 through 2011 time period covers the range of hydrologic conditions that may be observed into the future. (*See* Figure 4-4).

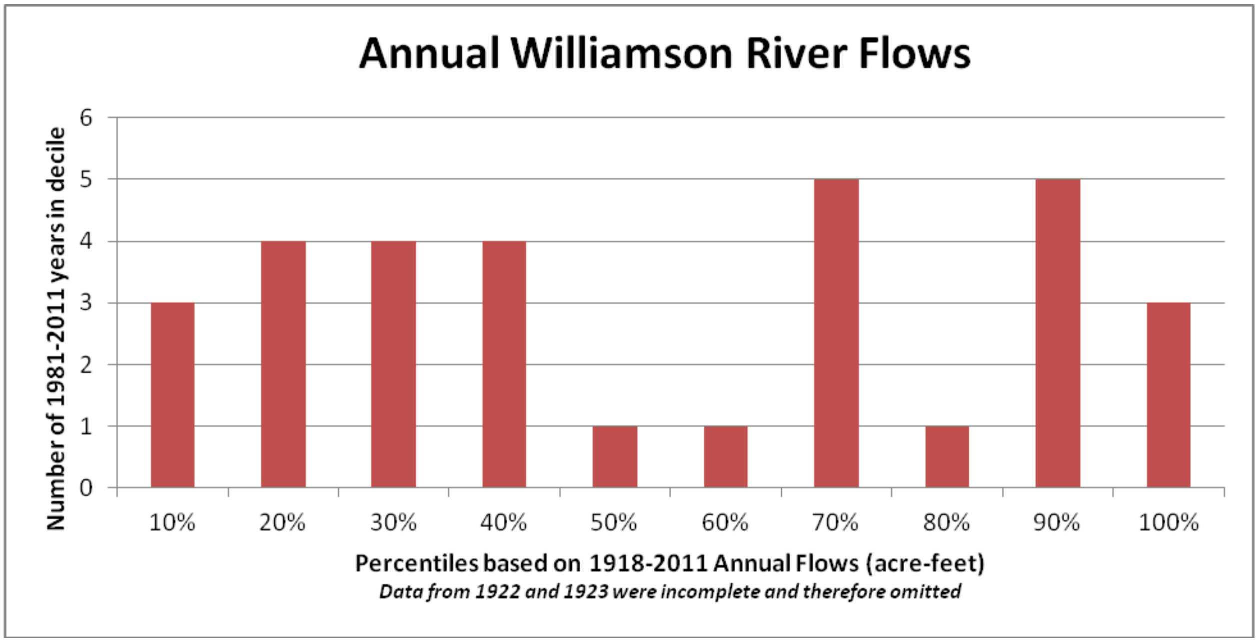

Figure 4-4. Distribution of 1981-2011 Upper Klamath Lake net inflow compared to Williamson River flows, 1918-2011.

4.2.1. Proposed Action Model Development

Reclamation incorporated the 1981 through 2011 dataset into WRIMS to assess the effects of the Proposed Action. WRIMS, formerly called CALSIM, is a generalized water resources modeling system for evaluating operational alternatives of large, complex river basins. Historical daily data for this Period of Record was reviewed and updated by comparing values recorded by Reclamation with other data sources, recalculating computed values, and disaggregating previously grouped delivery and inflow sources. The final data set used for the analysis was developed and reviewed by the Hydrology Team, mentioned in Section 3.5.

The working version of WRIMS that was used for the Project is referred to as the Klamath Basin Planning Model (KBPM). The KBPM encompasses the West Side of the Project from UKL to IGD. KBPM does not model the East Side of the Project, such as Clear Lake and Gerber

Reservoirs or the Lost River, although the net effects of East Side conditions on the Klamath River are included in the model via the gains and losses due to the LRDC. The KBPM also does not model explicit operational details for many facilities on the Klamath River such as IGD or other reservoirs owned and operated by PacifiCorp. Operation of the West Side of the Project was simulated over a range of hydrologic conditions using daily input data to obtain daily weekly, monthly, and annual results for river flows, project diversions (including deliveries to the LKNWR), and reservoir storage. Reclamation modeled the effects of the potential management action of operation of the West Side on UKL elevations and Klamath River flows for the period of October 1, 1980 through September 30, 2011. The resulting simulated hydrology represents the water supply available from the Klamath River system at the current level of development.

It's important to note that the KBPM is a planning tool that assisted in the development of the Proposed Action and all of the processes built into the model cannot be implemented during actual operations. For example, monthly distribution patterns were developed to simulate the delivery of the Project irrigation deliveries for the KBPM modeling exercise. These distribution patterns were developed by analyzing historical irrigation demand patterns and taking the average percent distribution for each month. Real-time implementation of the Proposed Action will not result in these same irrigation delivery distribution patterns. The actual distribution of the Project Supply[5] is heavily dependent upon current hydrologic and meteorologic conditions and will vary from year to year. This is just one example of how the processes built into a planning model cannot be implemented, and/or are not intended to be implemented, during actual operations.

A detailed description of the WRIMS model can be found in Appendix 4A-1, Model Documentation.

4.2.2. Water Supply Forecasts

Annual planning relies heavily on seasonal water supply forecasts provided by the NRCS in the form of net inflow forecasts for UKL. The water supply forecasts are developed based on antecedent streamflow conditions, precipitation, snowpack, current hydrologic conditions, a climatological index, and historic streamflow patterns (Risley et al. 2005. USGS Scientific Investigations Report 2005-5177). NRCS updates the forecasts for the season at the start of each month from January to June, with extra updates mid-month from March through June. The UKL inflow forecasts are used to estimate the seasonal net inflow to UKL through September, which is used to determine the volume of water to be reserved in UKL for the federally-listed suckers, water supply for the Klamath Project, and the March through September Klamath River Environmental Water Account (EWA[6]) volume for federally-listed coho salmon (discussed further in Section 4.3.2.2., Operational Approach). It's important to note that the NRCS UKL inflow forecasts are estimates and actual observed inflows can vary significantly from the forecasted inflow.

[5] Project Supply pertains to the amount of water supply for Klamath Project irrigation.
[6] EWA is the amount of water available for the Klamath River.

Table 4-1 shows past UKL net inflow forecasts from the NRCS. Forecasts have ranged from 158,000 acre feet (AF) during 1991 to over 1,145,000 AF during 1999. These volumes range from 24 to 174 percent of average values for the March through September time period (660,000 AF) for the 1981-2011 time period. Table 4-1 also shows what the observed historic inflows were for each year. These figures show that on average, the forecast values were 102 percent of the historic values, although values for individual years ranged widely from 68 percent in 1994 and 2004 to 223 percent in 1991.

A detailed description of the NRCS inflow forecasting procedures can be located at the following NRCS web sites: http://www.wcc.nrcs.usda.gov/factpub/wsf_primer.html and http://www.wcc.nrcs.usda.gov/factpub/intrpret.html.

Table 4-1. Natural Resources Conservation Service March 1st 50 percent exceedance Upper Klamath Lake inflow forecasts for March through September from 1981-2011.

Year	Forecasted UKL Inflow (Acre-Feet)	Forecast Percent of Average (Avg = 659,530 AF)	Observed UKL Inflow (Acre-Feet)	Observed Percent of Forecast
1981	446,455	68%	388,192	87%
1982	1,015,986	154%	1,005,248	99%
1983	1,028,666	156%	1,223,771	119%
1984	940,559	143%	1,140,051	121%
1985	810,364	123%	787,544	97%
1986	671,356	102%	868,124	129%
1987	500,440	76%	534,085	107%
1988	499,088	76%	418,796	84%
1989	771,063	117%	878,468	114%
1990	405,644	62%	445,474	110%
1991	157,949	24%	352,451	223%
1992	323,269	49%	233,872	72%
1993	862,340	131%	967,766	112%
1994	400,551	61%	273,514	68%
1995	580,022	88%	726,845	125%
1996	828,135	126%	814,589	98%
1997	901,939	137%	662,466	73%

Table 4-1. Natural Resources Conservation Service March 1st 50 percent exceedance Upper Klamath Lake inflow forecasts for March through September from 1981-2011.

Year	Forecasted UKL Inflow (Acre-Feet)	Forecast Percent of Average (Avg = 659,530 AF)	Observed UKL Inflow (Acre-Feet)	Observed Percent of Forecast
1998	874,790	133%	975,442	112%
1999	1,145,458	174%	1,040,052	91%
2000	826,962	125%	712,746	86%
2001	438,058	66%	353,859	81%
2002	604,513	92%	449,304	74%
2003	411,027	62%	471,597	115%
2004	677,336	103%	458,491	68%
2005	437,940	66%	457,383	104%
2006	979,879	149%	925,778	94%
2007	560,036	85%	528,278	94%
2008	702,737	107%	614,277	87%
2009	519,885	79%	501,448	96%
2010	467,064	71%	420,246	90%
2011	716,201	109%	815,395	114%

4.3. Proposed Action

The Proposed Action for 2013 to 2023 consists of three major elements to meet authorized Project purposes, satisfy contractual obligations, avoid jeopardy to listed species and adverse modification of critical habitat, and provide a range of flexibility for listed species and Project irrigators:

1. Store waters of the Klamath and Lost Rivers.

2. Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, subject to water availability; while maintaining lake and river hydrologic conditions that avoid jeopardizing the continued existence of ESA-listed species and adverse modification of designated critical habitat.

3. Perform O&M activities necessary to maintain Project facilities to ensure proper long-term function and operation.

Each of the elements of the Proposed Action is described in greater detail in the following sections.

4.3.1. Element One

Store waters of the Klamath and Lost Rivers.

4.3.1.1. Annual Storage of Water

The Project has two distinct areas, the West Side and the East Side. The West Side of the Project includes lands that are served primarily by the Klamath River system: water from UKL and the Klamath River. The East Side of the Project includes lands served only by water from the Lost River. The Project has three storage facilities. Two of the three storage facilities, Clear Lake and Gerber reservoirs, primarily serve the East Side. The other facility, UKL, serves the West Side. Figure 4-5 illustrates the delineation between the West and East Sides.

A typical Reclamation water project has the capacity to store large quantities of water during high inflow periods and subsequently make that water available to meet delivery needs in years with low inflows. The Klamath Project's primary storage reservoir, UKL, is shallow and averages only about six feet of usable storage when at full pool (approximately 515,000 AF), and thus does not have the capacity to carry over significant amounts of stored water from one year to the next. It also has limited ability to store higher than normal inflows during spring and winter months due to the low, vulnerable levees that surround UKL, so the system is highly dependent on actual monthly inflows in any individual year, and is predominately dependent upon snowpack (through tributary base flows) and groundwater flows (direct discharge to UKL) to sustain inflow throughout the irrigation season.

Reclamation proposes to store water in UKL and Clear Lake and Gerber Reservoirs year-round with a majority of the storage occurring during the October through April time period. In some years of high net inflows or non-typical inflow patterns, contributions to the total volume stored can also be significant in May and June. The majority of delivery from storage occurs during March through September, although some delivery does occur in October and November. The action of storing water through the winter creates rising lake elevations which usually peak between March and May.

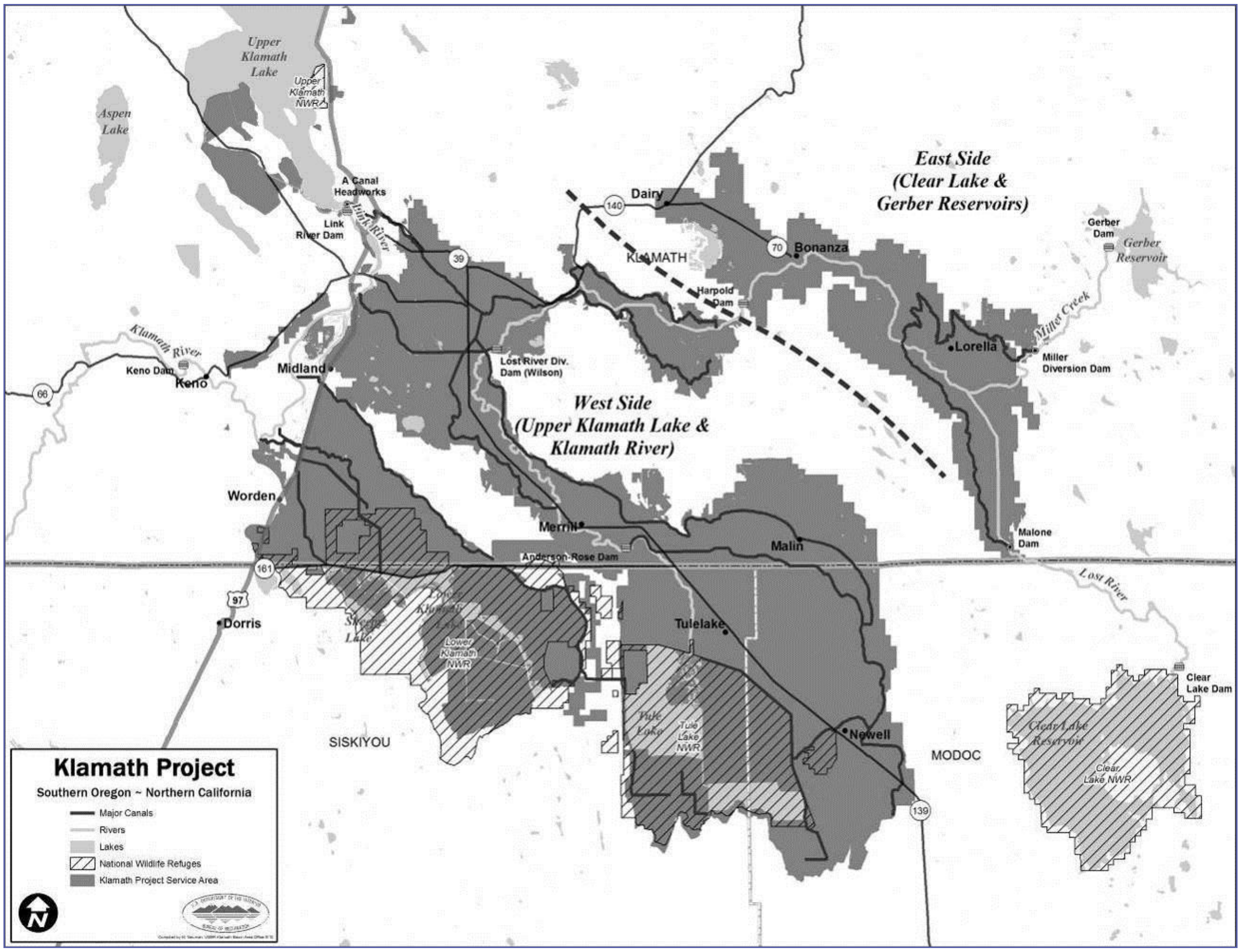

Figure 4-5. Map illustrating the delineation between the West Side and East Side of the Klamath Project.

4.3.2. Element Two

> *Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, subject to water availability, while maintaining lake and river hydrologic conditions that avoid jeopardizing the continued existence of ESA-listed species and adverse modification of designated critical habitat.*

Reclamation proposes to operate the Project consistent with historic operations. For analysis purposes, Reclamation has split the Project into two components, the West and East Sides. Releases made from East Side dams are typically not used to provide water for the West Side and water released and diverted from UKL for irrigation on the West Side is not used in the East Side due to facility limitations. The Project is operated so that flows of the Lost River and Klamath River are controlled except during high inflow periods. Water that is diverted from the UKL sub-basin for use within the West Side is reused several times before it returns to the Klamath River via the Klamath Straits Drain. Return flows from water delivered from the reservoirs on the East Side are also reused several times. The Project was designed based on this reuse of water. Note that the West Side and East Side references above are to Reclamation's

Klamath Project and do not refer to PacifiCorp's East Side and West Side power generation facilities located adjacent to Link River Dam.

4.3.2.1. Operation and Delivery of Water on the West Side of the Klamath Project

The West Side consists of approximately 170,000 acres of irrigable land and numerous reservoirs, dams, channels, canals, laterals, drains, and pumping plants. The West Side diverts water directly from UKL or from UKL via Keno Reservoir. Link River Dam on the south end of UKL is operated by PacifiCorp under agreement with Reclamation and regulates flow from UKL into the Link River. The Link River flows into Keno Reservoir, which is the start of the Klamath River.

Delivery of water to Project lands mainly occurs from early April through mid-October. However, some Project deliveries to the West Side of the Project take place during the months of October through March. Delivery facilities that provide winter irrigation and NWR water include Ady and North Canals. Station 48 can deliver water into November in some years at the end of the season to finish irrigation within TID.

Demands for irrigation supply and refuge deliveries during the consultation period are assumed to be similar to those that have occurred in the 31-year Period of Record for water-year 1981 through 2011, with the exception of 2001, which did not have typical deliveries. The irrigation "demand" is the amount of water required to fully satisfy the irrigation needs of the Project. These historic demands were included in the model runs that define the expected river flows and UKL elevations. Demands during this 31-year period exhibit a large range of hydrologic and meteorologic conditions and the various demands during this period are reasonably expected to cover the range of conditions that are expected to be observed during the 10-year period of this consultation.

The following is a brief description of the major Project delivery facilities associated with the West Side.

The A Canal diverts water directly from UKL 1,700 feet upstream of Link River Dam, and delivers irrigation water, either directly or indirectly through return flows, to a large portion of the Project. The Lost River Diversion Dam, located on the Lost River near the town of Olene, Oregon, diverts water from the Lost River into the LRDC for irrigation and flood control of Tule Lake reclaimed lands. The LRDC begins at the Lost River Diversion Dam and travels in a westerly direction terminating at Keno Reservoir. The LRDC is designed so that water can flow in either direction depending on operational requirements, and during irrigation season the predominant direction of flow is from the Klamath River system to the Lost River system. During the non-irrigation season, flows in the Lost River upstream of the Lost River Diversion Dam are diverted to the Klamath River to prevent flooding in the Tule Lake area. Miller Hill Pumping Plant and Station 48 Turnout are both located on and take water from the LRDC. Anderson-Rose Diversion Dam is located on the Lost River downstream of the Lost River Diversion Dam and provides the necessary forebay for water delivery to the J Canal headworks, which is the main distribution canal for TID. Ady and North canals divert water from Keno Reservoir to the Lower Klamath Lake area and serve Klamath Drainage District, LKNWR, and the Area K Lease Lands. Refer to Figures 1-1, 4-1, and 4-5 and Appendix 1-A for maps showing several of these Project features.

4.3.2.2. Operational Approach

Reclamation is proposing to manage water deliveries for facilities located in the West Side of the Project consistent with historic operations. This section of the Proposed Action provides a general overview of the operational approach for the Proposed Action and additional details regarding the fall/winter and spring/summer time periods are discussed below in their respective sections.

Fall/winter water management, October through February, would operate using a formulaic management approach focused on meeting the needs of coho salmon downstream while increasing water storage in UKL and providing fall/winter water deliveries to the Project and LKNWR. This approach attempts to ensure adequate water storage and sucker habitat in the lake while providing river flows that mimic natural hydrologic conditions based on current conditions in the upper Klamath Basin. *See* Section 4.3.2.2.1., Fall/Winter Operations, Appendix 4A-1, Model Documentation, and Appendix 4A-2, Key Model Variables, for in-depth details regarding the fall/winter water management approach.

Spring/summer water management would remain consistent with historic operations by proposing to maintain full irrigation deliveries in accordance with existing contracts, contingent upon available water supplies. Reclamation will evaluate the total available UKL water supply and determine in early spring a supply of water to be reserved in UKL for ESA-listed suckers (UKL Reserve[7]), the amount of water available for the Klamath River (EWA), and the available water supply for Project irrigation (Project Supply). The division of the total available UKL water supply between UKL Reserve, EWA, and Project Supply was determined based on an analysis of available information regarding ESA-listed species needs and the ecologic needs of the species identified in previous BOs. Past BOs identified that previous Proposed Action's submitted by Reclamation were inadequate to avoid jeopardizing the continued existence of ESA-listed species. Based on available information and the guidance provided in past BOs, Reclamation has decided to incorporate a real-time management concept into current Project operations to lessen the impacts of Project operations on ESA-listed species.

A key driver and benefit of this concept is greater water certainty in water supply for the Project and the flexibility to meet real-time species needs. This real-time management approach for UKL and the Klamath River attempts to optimize the ecologic benefit of the available water supply, resulting in the ability to maximize the amount of remaining water available for the Project. In some instances, dry hydrologic conditions characterized by limited precipitation, runoff, and inflows to UKL may create shortages in the total available UKL water supply, which can result in a Project Supply that is less than the full irrigation demand. *See* Figure 4-6 for a graph of model outputs for EWA and Project Supply based on available UKL water supply with the lines indicating overall trend. Figure 4-7 shows the volumes simulated for the main parts of

[7] UKL Reserve pertains to the early spring supply of water to be reserved in UKL for ESA-listed suckers.

the water supply. *See* Section 4.3.2.2.2., Spring/Summer Operations, Appendix 4A-1, Model Documentation, and Appendix 4A-2, Key Model Variables, for in-depth details regarding the spring/summer operational approach.

Reclamation is proposing to use the water management process described here to provide guidance on making releases at Link River Dam based on a hydrologic indicator of upper Klamath Basin conditions. The hydrologic indicator used is based on actual flows that occur in the Williamson River upstream of UKL. The intent of this method is to create a river hydrograph downstream of IGD that is a better approximation of a natural flow regime that reflects actual hydrologic conditions and variability occurring in the Williamson River and the upper Klamath Basin.

The Williamson River flow gauge, maintained by the U.S. Geological Survey (USGS Gauge #11502500), has a consistent and reliable dataset for the water-year 1981 through 2011 period (which, as previously mentioned, is the period that was utilized to simulate the Proposed Action). In addition, the flow gauge is expected to remain in operation and the continued reliability and availability of flow data is an important consideration to retain the ability to implement the Proposed Action in the future. The Williamson River is also the largest single tributary to UKL and provides for a good hydrologic indicator of current hydrologic conditions in the upper Klamath Basin. For these reasons, flows in the Williamson River were selected to provide for a consistent and reliable indicator of actual hydrologic conditions in the upper Klamath Basin.

This operational method is expected to result in significant increased variability in flows downstream of IGD and in UKL elevations compared to the rigid operational strategies that have been implemented in the past. Past operational strategies have resulted in static flows downstream of IGD for long durations and UKL operations that were targeted to meet rigid minimum elevations. This operational strategy will provide for variability of Klamath River flows on much shorter time steps and UKL elevations that vary based on the actual hydrologic conditions observed each year. For several graphical examples of the anticipated variability in IGD flows and UKL elevations, *see* Appendix 4A-3, Proposed Action Model Output Graphs. The model output graphs provided in Appendix 4A-3 are included to provide examples of how the annual hydrographs might look. Real-time operations will not exactly replicate the modeled results and actual flow and elevation variability will differ during real-time operations.

The daily IGD target flows will be implemented one week after the hydrologic conditions are observed in the upper Klamath Basin and the Williamson River. The one week period between when the flows at the Williamson River gauge are observed and when the flows will occur at IGD is roughly the time period that it would take for flows to reach IGD from the Williamson River flow gauge under natural hydrologic conditions. The actual transit time under natural conditions would be more or less than one week depending on the magnitude of the flow rate, elevation of UKL, and the hydrologic conditions downstream of UKL. No attempt was made to calculate transit time under natural conditions and the one week delay is not intended to precisely replicate natural flow conditions of the Klamath River. Rather, the one week lead time is required for IGD flow schedule planning purposes and happens to roughly approximate what the natural transit time from the Williamson River flow gauge to IGD would be. All IGD target flows will be determined and coordinated with PacifiCorp one week in advance.

Since the Williamson River flows are used to determine the LRD releases, Williamson River inflow forecasts will be used to provide an additional projection of the likely LRD and resulting IGD flows for an additional one week period. This one week LRD and IGD flow projection is intended to provide additional advanced planning opportunities for resource managers and PacifiCorp. However, this is an estimate and the actual LRD and IGD target flows will be determined after the upper Klamath Basin hydrologic conditions, Williamson River flows and LRD to IGD accretions are actually observed.

The releases at IGD are ultimately the result of the daily Link River Dam target releases, Link River Dam to IGD accretions, and the management of the Klamath Hydroelectric Project by PacifiCorp. Since precise measurements of accretions between Link River Dam and IGD are not available, PacifiCorp will make every attempt to estimate these accretions and add them to the Link River Dam target releases on a near real-time basis. PacifiCorp will be provided flexibility in passing the effects of the accretions downstream of IGD, but it is expected that the accretions will be passed through the Klamath Hydroelectric Project in a manner that is generally consistent with the timing and magnitude of when the accretions occur. PacifiCorp committed to coordinating with Reclamation to meet the flow related requirements as described in the 2010 NMFS BO on Project operations as one of the conservation actions in their coho Habitat Conservation Plan. PacifiCorp has successfully coordinated with Reclamation to implement the requirements associated with the 2010 NMFS BO for the last 3-years and Reclamation expects this close coordination to continue for the implementation of Project requirements resulting from this consultation. In addition, emergencies may arise that cause the need for PacifiCorp to deviate from the IGD release target. These emergencies may include, but are not limited to, flood control, facility, and regional electrical service emergencies. Reclamation will closely coordinate with PacifiCorp should the need to deviate from the IGD flow target be identified due to an emergency. Such emergencies occur infrequently and are not expected to significantly influence flows downstream of IGD.

In the event of gauge failure, professional judgment will be used in combination with all relevant hydrologic data to estimate the Williamson River flow, UKL elevation and inflow, IGD releases, and/or Link River Dam to IGD accretions. USGS gauge failures occur infrequently and every attempt will be made to coordinate with USGS to appropriately estimate flow and/or elevation values whenever a gauge failure occurs.

This approach will require significant coordination and organization to implement, and Reclamation will assign an EWA Manager to facilitate implementation of the Proposed Action. The primary role of the EWA Manager is to coordinate with the various stakeholders in a near real-time manner to ensure that the Proposed Action is implemented as intended and to provide guidance on how to manage the EWA to best meet the needs of coho salmon in the Klamath River while balancing the needs of listed suckers in UKL. In addition to the above mentioned tasks, the EWA Manager will also manage a Flow Account Scheduling Technical Advisory (FASTA) Team, integrate and synthesize technical recommendations from individual FASTA Team members, and provide flow management recommendations. *See* Section 4.3.4., Implementing Environmental Water Account Management, for additional details related to the EWA Manager, the FASTA, and EWA management.

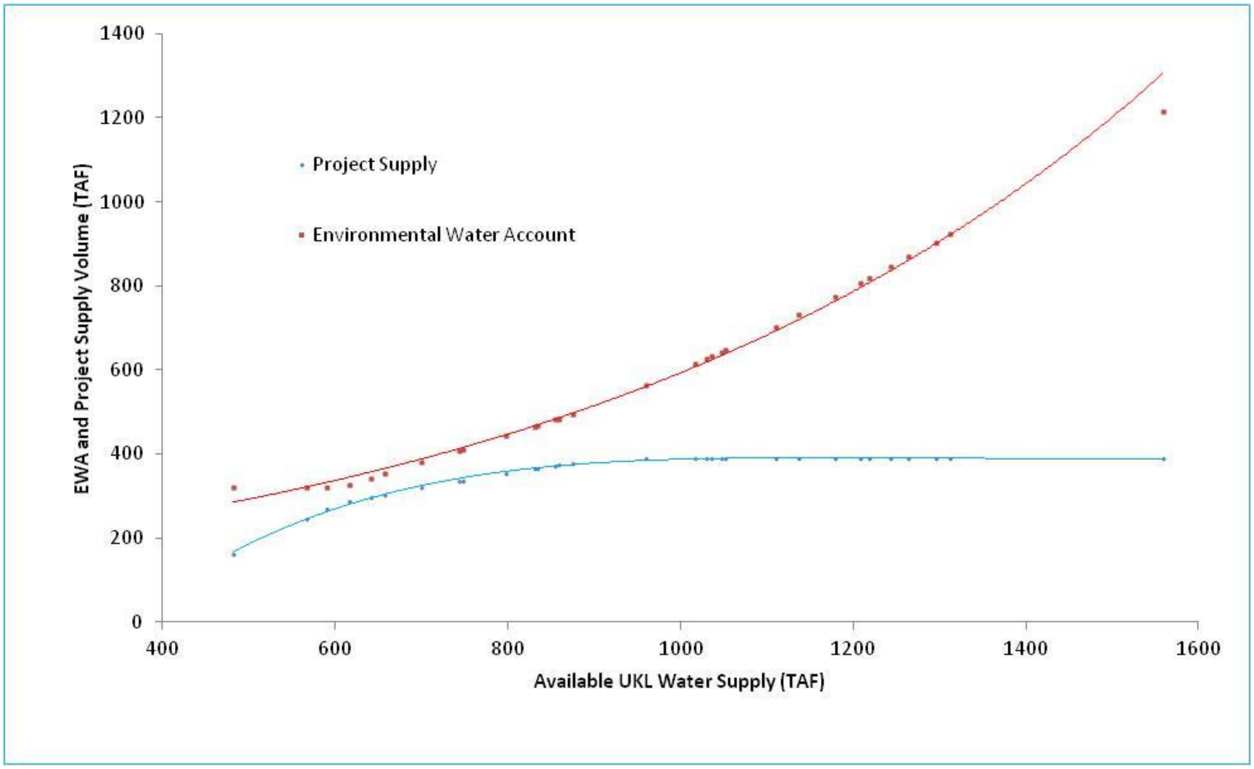

Figure 4-6. Environmental Water Account and Project Supply based on Upper Klamath Lake supply. Graph based on the Proposed Action model run output data.

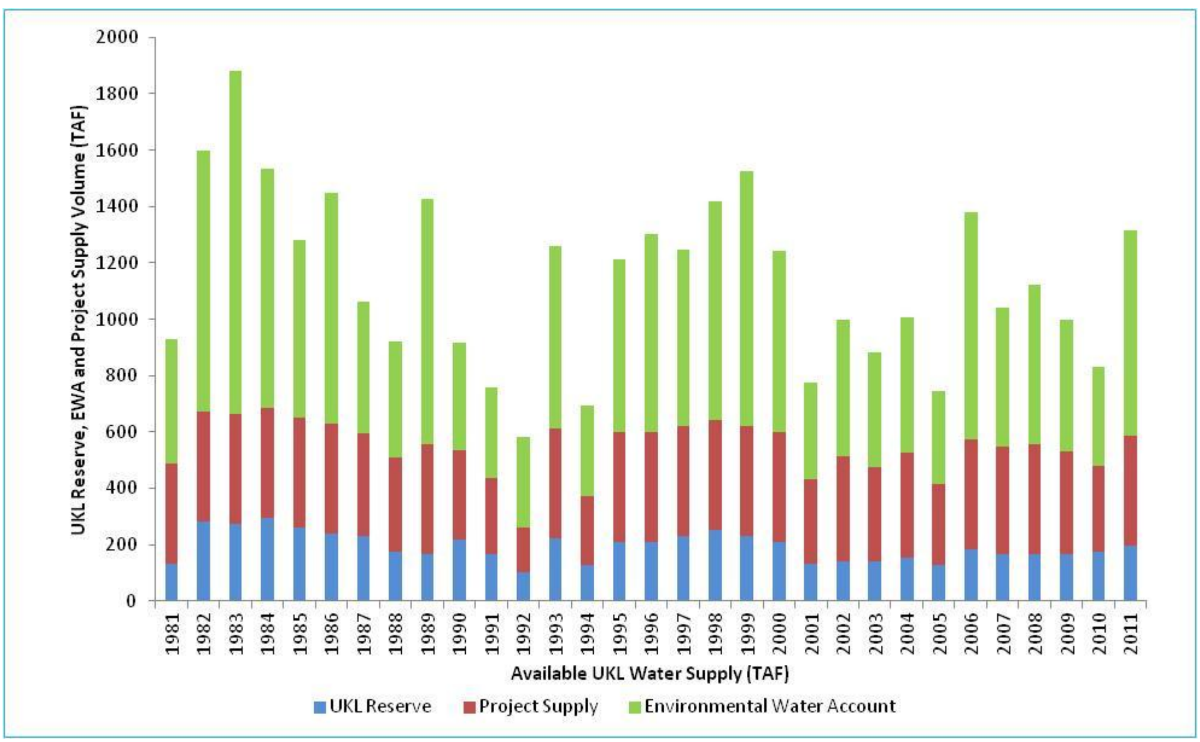

Figure 4-7. Upper Klamath Lake Reserve, Environmental Water Account, and Project Supply based on available Upper Klamath Lake water supply. Graph based on the Proposed Action model run output data.

4.3.2.2.1. Fall/Winter Operations

Reclamation will use the following water management procedure to identify instream flow releases at LRD based on a hydrologic indicator of recent conditions during the fall/winter period. The following description of the fall/winter management procedure is intended to provide a more in-depth summary of the fall/winter operational procedure than the text above. However, this is not an exhaustive description and additional details can be located in Appendix 4A-1, Model Documentation. Also, *see* Figure 4-8, Fall/Winter operations flow chart, for a graphical depiction of the fall/winter management process.

The fall/winter Klamath Project operational procedure distributes the available fall/winter UKL inflows between the following:

1. Increase UKL elevation to meet ESA-listed habitat needs throughout the fall/winter period and the following spring/summer period, and increase storage for spring/summer EWA releases and irrigation deliveries.

2. Release sufficient flow from Link River Dam to meet ESA-listed species needs in the Klamath River downstream of IGD.

3. Provide fall/winter Project irrigation deliveries:
    a. Klamath Drainage District (Area A2 – serviced by North Canal and Ady Canal)
    b. Lease Lands in Area K (within area A2 – serviced by Ady Canal)
    c. LKNWR (serviced by Ady Canal)

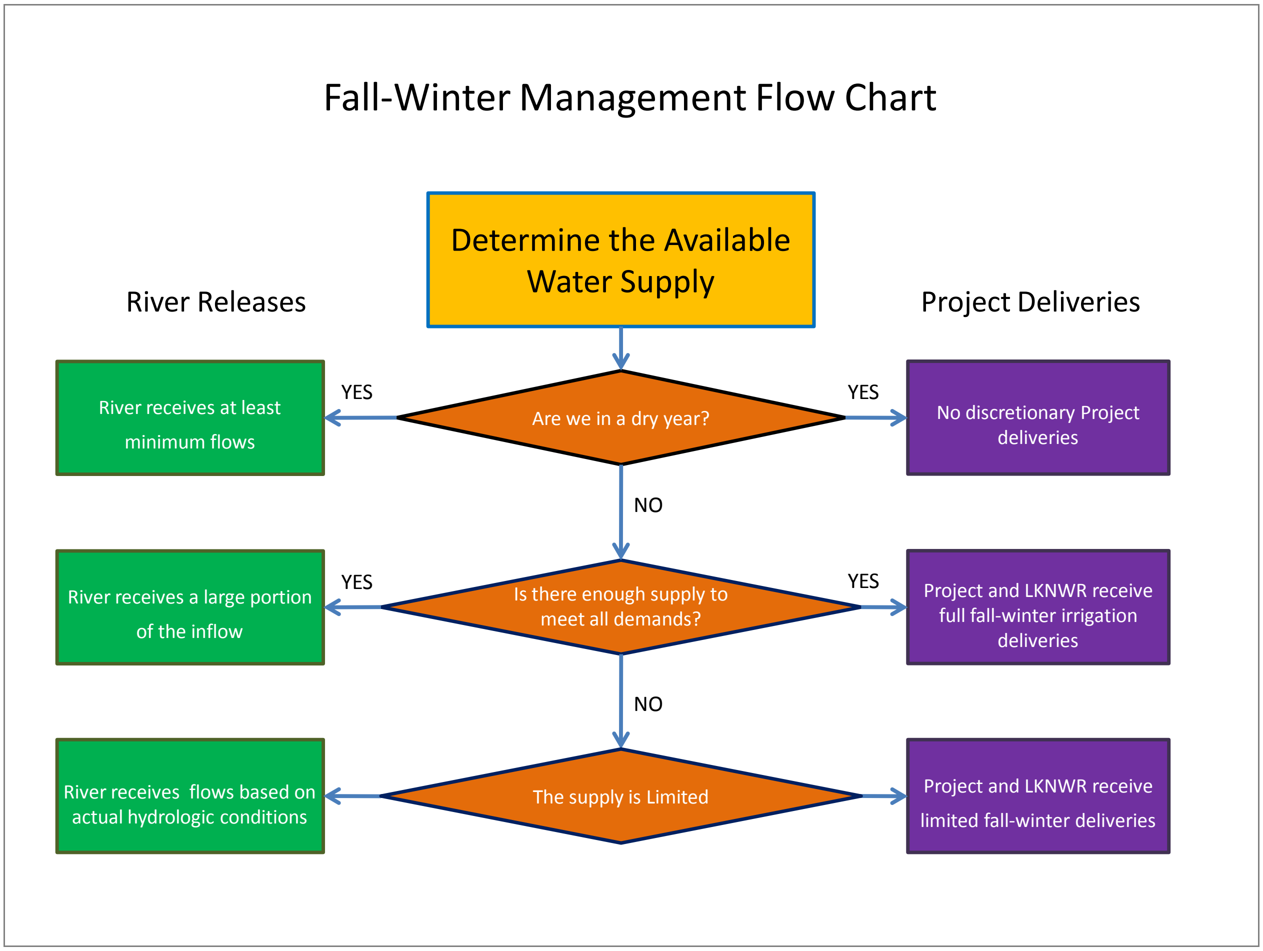

Figure 4-8. Fall/Winter management overview flow chart.

To satisfy these objectives, Reclamation will identify a release target from LRD by means of a series of context based real-time equations using the Williamson River as a hydrologic indicator. As mentioned, the distribution of UKL inflows during the fall/winter is determined using the Williamson River as a hydrologic indicator, but is also affected by how fast UKL is filling and the current accretions to the Klamath River between LRD and IGD. All fall/winter releases from UKL for IGD flows are computed as a proportion of the Williamson River inflow, adjusted for current hydrologic conditions and any portion of the EWA that was carried over from the preceding spring/summer. The LRD target flow determination equation varies by month and current hydrologic conditions, as detailed in the text below. *See* Table 4-2 for the equations used to determine the LRD target release rate during the different portions of the fall/winter period.

The equations in Table 4-2 rely on five variables: 1) the prior day's Williamson River flow; 2) the base proportion of that flow to be released from LRD; 3) a coefficient adjusting that flow according to the fill rate of UKL; 4) in dry conditions, a coefficient adjusting the flow according to downstream accretions; and 5) additional flow from carry-over EWA water during October and November. The following paragraphs describe how these factors affect the release rates from LRD.

To calculate the LRD daily flow release for each day during the fall/winter, the proportion of the Williamson River inflow used to calculate the daily LRD target release is adjusted based on the magnitude of the current flow rate of the Williamson River. The greater the flow rate of the Williamson River, the greater the proportion of the total daily Williamson River flow is targeted for release at LRD. The previous day's inflow to UKL from the Williamson River is multiplied by the appropriate proportion from Table 4-3 (Williamson River release target proportion) to calculate an initial LRD flow release. Different adjustments are then made to the initial LRD flow release calculation depending on the date and relative wetness of recent hydrologic conditions.

Releases from IGD can be greatly affected by the accretions downstream of LRD. In wetter hydrologic patterns, or during periods immediately following storms, the accretions between LRD and IGD can increase substantially and the initial LRD flow release can be adjusted to account for these changing conditions in LRD to IGD accretions (Table 4-4). In addition, the proportion of the Williamson River flow intended for release at LRD can be adjusted from November 16 through February to account for the fill trajectory of UKL during drier hydrologic conditions (Table 4-5). The LRD target flow is not adjusted to account for the fill trajectory in UKL until November 16, because October through November 15 is a transitional period in which UKL elevation stops declining and starts to re-fill. In addition, October through November 15 is a biologically sensitive time (e.g. coho salmon spawning and egg incubation) in the Klamath River downstream of IGD, and subject to highly variable accretions between LRD and IGD. Therefore, no adjustments are made to enhance UKL re-fill during this period.

October 1 through November 15 time period

During the October 1 through November 15 time period the initial LRD flow release is calculated based on the Williamson River inflows to UKL and adjusted based on LRD to IGD accretions and for EWA carry over water that is distributed during October and/or November.

November 16 through November 30

During the November 16 through November 30 time period the initial LRD flow release is adjusted differently depending on the UKL cumulative net inflow. A cumulative UKL net inflow index less than 0.3 indicates that drier hydrologic conditions exist and flows from LRD are increased to account for lower LRD to IGD accretions. A cumulative UKL net inflow index greater than 0.3 indicates that wetter hydrologic conditions exist, and increased flows from LRD will not be needed due to elevated LRD to IGD accretions that are associated with wetter hydrologic conditions. The initial LRD flow release can also be adjusted to account for how fast UKL is filling. If the fill rate of UKL is faster or slower than that required to reach 4,142.8 feet by March 1st, then the initial LRD flow release is increased or decreased accordingly. In addition, any EWA carry over water that is distributed during this portion of November is added to the adjusted LRD flow release.

December 1 through February 28

During the December 1 through February 28 time period the initial LRD flow release is adjusted differently depending on the UKL cumulative net inflow. A cumulative UKL net inflow index less than 0.3 indicates that drier hydrologic conditions exist and flows from LRD are increased to account for lower LRD to IGD accretions. A cumulative UKL net inflow index greater than 0.3

indicates that wetter hydrologic conditions exist, and increased flows from LRD will not be needed due to elevated LRD to IGD accretions that are associated with wetter hydrologic conditions. The initial LRD flow release can also be adjusted to account for how fast UKL is filling. If the fill rate of UKL is faster or slower than that required to reach 4,142.8 feet by March 1st, then the initial LRD flow release is increased or decreased accordingly.

Table 4-2. Calculation of Fall/Winter Link River Dam target releases.

Condition	Equation
October through November 15	(Will_prop · Will_Riv_inf-1 · Accrete_adjust) + OctNov_augment
November 16 through 30, UKL_cum_inf_ind < 0.3 (dry)	(Will_prop · Will_Riv_inf-1· Fill_rate_adjust · Accrete_adjust) + OctNov_augment
November 16 through 30, UKL_cum_inf_ind > 0.3 (wet)	(Will_prop · Will_Riv_inf-1· Fill_rate_adjust) + OctNov_augment
December through February, UKL_cum_inf_ind < 0.3 (dry)	Will_prop · Will_Riv_inf-1 · Fill_rate_adjust · Accrete_adjust
December through February, UKL_cum_inf_ind > 0.3 (wet)	Will_prop · Will_Riv_inf-1· Fill_rate_adjust

The terms for Tables 4-2, 4-3, 4-4, and 4-5 are described in greater detail below and in Appendix 4A.

"UKL_cum_inf_ind" is a UKL cumulative net inflow index that provides a relative indication of how wet or dry hydrologic conditions have been based on the current cumulative UKL net inflow.

"Will_prop" is the proportion of yesterday's Williamson River flow that is targeted for release from Link River Dam. The proportion varies depending on the flow rate for the Williamson River on that day.

Table 4-3. Williamson River release target proportion.

October		November		December		January		February	
WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop	WillQ-1 (cfs)	Will_prop
0	1.0	0	1.0	0	0.85	0	0.85	0	0.85
500	1.0	500	1.0	450	0.85	450	0.85	450	0.85
650	1.25	1173	1.25	800	0.9	800	0.9	800	0.9
1000	2.0	3192	2.0	1000	1.5	1000	1.5	1000	1.5
4000	2.3	4000	2.3	2000	1.9	2000	1.9	2000	1.9
9999	2.3	9999	2.3	4000	2.3	4000	2.3	4000	2.3
				9999	2.3	9999	2.3	9999	2.3

"$Will\_Riv\_inf_{-1}$" is the Williamson River flow volume for the previous day.

"Accrete_adjust" is an adjustment to LRD releases based on net accretions between LRD and IGD. Low net accretions cause a need for higher LRD releases in order to produce target flows at IGD. The Accrete_adjust variable increases LRD releases from October through November 15 in all years, but during November 16 through December flow increases are only applied when conditions are relatively dry ($UKL\_cum\_inf\_ind_{-1} < 0.3$).

Table 4-4. Net accretion adjustment factor.

October		November		December		January		February	
Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust	Net_ accrete (cfs)	Accrete_ adjust
-58	1.2	43	1.2	60	1.2	140	1.0	303	1.0
198	1.2	163	1.2	171	1.2	258	1.0	354	1.0
397	1.0	377	1.0	342	1	410	1.0	525	1.0
510	1.0	494	1.0	415	0	473	0	589	0
585	0.4	566	0.4	9999	0	9999	0	9999	0
9999	0.4	9999	0.4						

"OctNov_augment" is based on the portion of the EWA that was carried over from the previous spring/summer season. The carryover volume of water is distributed during October and November, and will be added to the Link River Dam target release in these months.

"Fill_rate_adjust" adjusts the proportion of the Williamson River flow for release at Link River Dam from November 16 through February to account for the fill trajectory of UKL.

Table 4-5. Fill rate adjustment factor.

Fill_rate_diff (feet/day)	Fill_rate_adjust_wet	Fill_rate_adjust_dry
-999	0.6	0.2
-0.02	0.6	0.2
0	1.0	1.0
0.03	1.4	1.0
999	1.4	1.0

"Fill_rate_diff" is the difference between the recent fill rate of UKL and the average fill rate needed to reach 4,142.8 feet on March 1.

During real-time fall/winter operations, a daily average Link River Dam target release flow will be calculated according to the equations discussed above and listed in Table 4-2, Calculation of Fall/Winter Link River Dam target releases. This daily average Link River Dam target release will then be translated into a daily IGD flow target based on current estimates of accretions between Link River Dam and IGD. As mentioned above, these daily IGD target flows will be implemented one week after the inflows are observed in the Williamson River.

Once the LRD and IGD daily target releases are determined, the UKL refill rate is evaluated to calculate the fall/winter water available for delivery to Area 2 of the Project and LKNWR. As with the LRD daily target release, the availability of fall/winter water for delivery is evaluated on a daily basis. If UKL is on track to reach an elevation of 4,142.8 feet by the end of February, water is made available for delivery to Area 2 and/or LKNWR. The timing of requested water deliveries to Area 2 and LKNWR during the fall/winter period varies from year to year depending on current and preceding weather and hydrologic conditions. Therefore, the amount of water determined to be available each day, and could have been diverted but was not, accumulates in a fall/winter Project account to be delivered to Area 2 and/or LKNWR when/if the demand exists later in the season. This volume of water is removed from the UKL volume/elevation that is used to determine LRD target releases for the following days and can subsequently be delivered to Area 2 and/or LKNWR. Any of this volume that is not delivered by the end of February remains in UKL and is made available for use during the spring/summer operations period.

In October and November, there is overlap between the spring/summer and fall/winter operation because Area 1 and/or LKNWR will divert a portion of the spring/summer Project Supply during these months, and some of the EWA can be carried over from the preceding spring/summer period for distribution during October and November. The delivery of spring/summer water doesn't preclude the delivery of fall/winter water during the months of October and November.

Therefore, the spring/summer and fall/winter diversion accounts must be kept separate during the overlap period.

It is important to note that real-time hydrologic conditions will be closely monitored during the fall/winter to ensure that flood control thresholds for UKL are not exceeded and adequate capacity remains in UKL to accommodate high runoff events, especially during rain on snow events. During high runoff events, deviations from the fall/winter management procedure may be required in order to protect public safety and the levees surrounding UKL. In addition, other unforeseen emergency and/or facility control issues could arise that would require deviations from the fall/winter management procedure. In such cases, Reclamation will return to the fall/winter management procedure as soon as the emergency or facility control issue is resolved. *See* Table 4-10 below in Section 4.3.2.2.3. UKL Flood Release Threshold Elevations for a table of UKL flood control thresholds and additional considerations regarding flood control for UKL.

4.3.2.2.2. Spring/Summer Operations

The previous section described the fall/winter operations which are the first half of each water year, where this section describes the second half of each water year, which covers the irrigation season. The Project irrigation season runs from March 1 through September 30; however, spring/summer irrigation often continues into October and November depending on the weather, crops planted, and the hydrologic conditions at the end of each water year.

The spring/summer operations, or irrigation season operations, will remain consistent with historic Project operations, while providing greater certainty for Project Supply and maintaining lake and river conditions that avoid jeopardizing the continued existence of ESA-listed species and adverse modification of designated and proposed critical habitat and does not preclude recovery of the species listed under the ESA. Spring/summer operations are controlled by first defining the total available water supply (UKL Supply), which is based on the current available supply in UKL and the forecasted UKL inflows during the March through September period. The UKL Reserve, Project Supply, and EWA are based on the UKL Supply. All water released from UKL through either LRD or the A Canal is accounted for against the Project Supply or the EWA, which also includes flood control releases. Details for determination of the UKL Supply, Project Supply and EWA are included in the text below. *See* Figure 4-9 for a schematic of the average relative volumes of water that go to EWA, Project deliveries, and remain in UKL during the spring/summer period. *See* Figure 4-10, Spring/Summer operations management overview flow chart, for an overview of the water supply determination process. *See* Appendix 4A-3, Proposed Action Model Output Graphs for examples of how the annual hydrographs might look. Actual flow and elevation variability will differ during real-time operations.

The UKL Reserve, Project Supply, and EWA are calculated on March 1 and April 1 with updates on May 1 and June 1. The March 1 and April 1 determination of UKL Reserve, Project Supply, and EWA divides up the UKL Supply early in the season to help the irrigators and River managers plan out the spring and summer seasons. The May and June updates manage for the change in supply by adjusting the UKL Reserve, EWA and/or Project Supply. The steps for determining the UKL Reserve, Project Supply, and EWA are below. Additional details and key model variables referenced throughout this section are defined in Appendix 4A-2. All releases from UKL will be accounted for and attributed to either the EWA or the Project Supply. Details regarding the accounting for EWA releases, as well as Project and LKNWR deliveries, are provided in Section 4.3.4., Implementing Environmental Water Account Management.

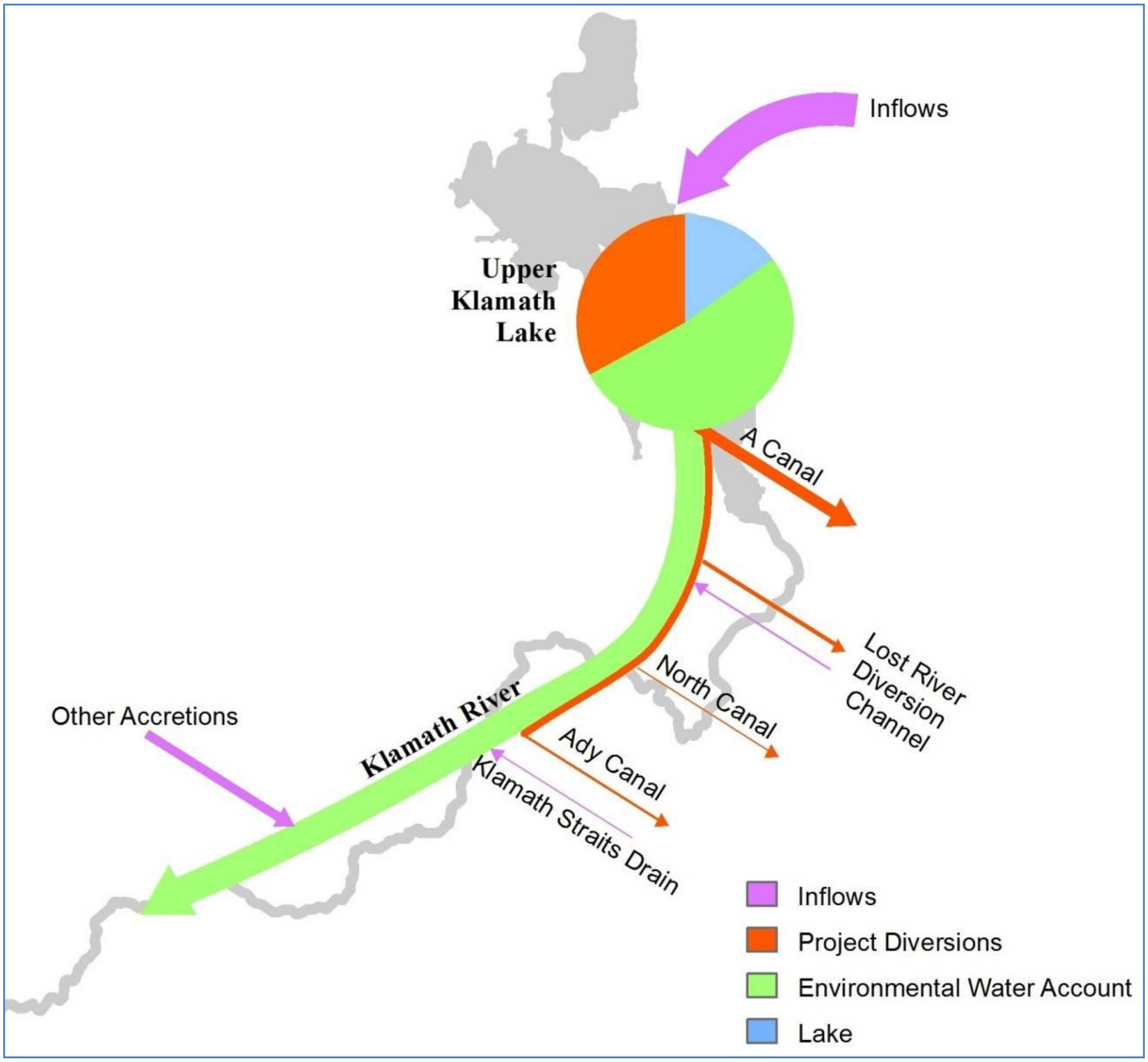

Figure 4-9. Schematic of Spring/Summer Environmental Water Account, Project Supply, and Upper Klamath Lake Reserve. The size of the pie chart and lines are proportional to average volumes of water.

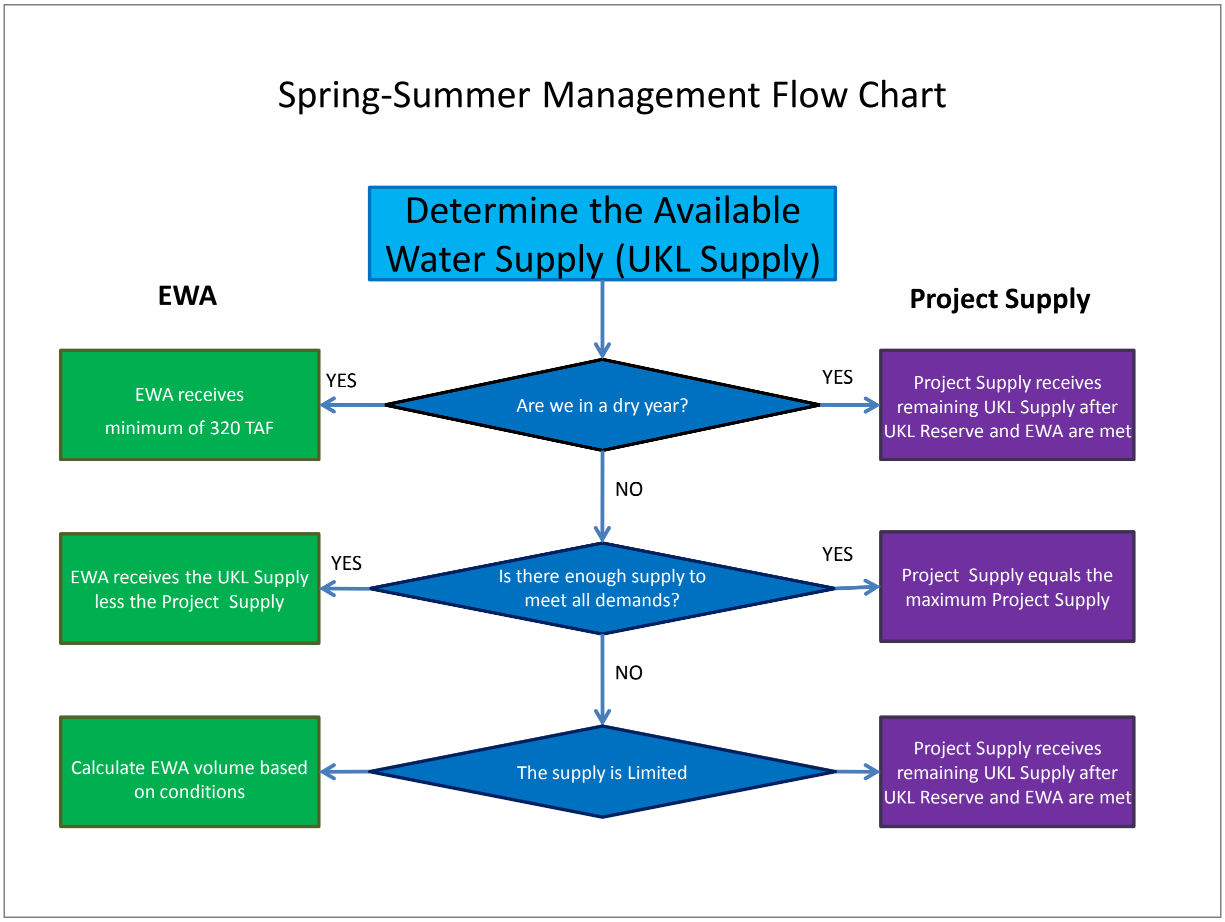

Figure 4-10. Spring/Summer operations management overview flow chart.

The UKL Supply is determined on the 1st of each month for March through June using the most current forecasted net inflow, the end of February storage, and the end of September target elevation. The equation to determine the UKL Supply is as follows:

UKL Supply = [End of February UKL Storage] + [forecasted UKL inflow for March through September] – [End of September UKL Storage Target]

The forecasted UKL inflow for March through September changes each month and is calculated as follows:

- March = [March 1st 50% exceedance inflow forecast for UKL net inflows for March through September]

- April = [April 1st 50% exceedance inflow forecast for UKL net inflows for April through September] + [Actual Inflows that Occurred in March]

- May = [May 1st 50% exceedance inflow forecast for UKL net inflows for May through September] + [Actual Inflows that Occurred in March] + [Actual Inflows that Occurred in April]

- June = [June 1st 50% exceedance inflow forecast for UKL net inflows for June through September] + [Actual Inflows that Occurred in March] + [Actual Inflows that Occurred in April] + [Actual Inflows that Occurred in May]

The **End of September UKL Storage Target** is the supply of water to be reserved in UKL for ESA-listed suckers (UKL Reserve) and is determined each month, March through June, based on the previous calculation for the forecasted UKL inflow for March through September using Table 4-6 below. The minimum UKL end of September elevation target is 4,138.1 feet. Linear interpolation is used for values not shown.

Table 4-6. Upper Klamath Lake end of September storage targets based on forecasted inflow.

March through September Forecasted Inflow (thousand acre-feet)	End of September Storage Target (feet)
210	4,138.10
310	4,138.10
620	4,138.20
830	4,138.35
1030	4,138.54
1240	4,138.75

The EWA is determined on the 1st of each month for March through June using the most current UKL Supply calculated above and will likely change on the 1st of April, May, and June when updated. The percentage of the total UKL Supply that is dedicated to EWA is based on the size of UKL Supply and is listed in Table 4-7 below. The percentage of UKL Supply that is dedicated to EWA increases as the UKL Supply increases. If the UKL Supply is less than 600 TAF, the calculated EWA from the percentages listed in Table 4-7 results in a volume less than 320 TAF. When this is the case, the EWA will be set to 320 TAF regardless of the size of the UKL Supply.

Table 4-7. Environmental Water Account based on Upper Klamath Lake Supply.

Upper Klamath Lake Supply (thousand acre-feet)	Environmental Water Account Percentage
500	0.53
600	0.53
900	0.57
1,100	0.63
1,300	0.70
1,500	0.78
9,999	0.78

A preliminary Project Supply is initially determined on March 1st. The Project Supply is calculated by taking the difference between the UKL Supply and the EWA.

Project Supply = UKL Supply – EWA

On April 1st the Project Supply is recalculated based on the April 1st UKL Supply. The Project Supply can go up or down on April 1st from the preliminary determination made on March 1st. The April 1st Project Supply determination is "locked in" and the Project Supply cannot go down from this value due to the May and June UKL Supply updates. The Project Supply is subsequently recalculated on May 1st based on the current UKL Supply and can go up from the April determination, but cannot go down. The final Project Supply update occurs on June 1st. If the June 1st Project Supply calculation results in a smaller Project Supply than the May update, then the Project Supply can be reduced, but cannot be reduced to less than the value determined on April 1st. The June 1st Project Supply calculation is the final Project Supply determination of the water year and is the official supply that is fixed though the remainder of the irrigation season and will be made available to the West Side of the Project from UKL. If the UKL Supply decreases following April 1st, and the EWA is at the minimum of 320 TAF, the Project Supply will remain at the April 1st determination and the decrease in supply will come out of UKL storage. This occurrence was observed once in the 1981 through 2011 period for the Proposed Action model run and is not be expected to occur frequently during real-time operations. If it appears that this decrease in storage will result in UKL elevations less than 4,137.5 feet, then Reclamation will adjust discretionary deliveries to the Project to prevent the UKL elevation from dropping below 4,137.5 feet.

Note that the Project Supply is only the supply of water to be made available from UKL and does not take into account contributing flows from the Lost River system. In other words, any Project return flows via the Lost River system that are diverted for irrigation do not count against the Project Supply from UKL. Since only the water originating from UKL counts towards the Project Supply, the amount of return flows from the Lost River that are diverted by the Project will be evaluated on a daily basis and subtracted from the total Project diversion to compute the daily Project Supply usage. In order to accurately characterize the effects of Project deliveries on UKL and the Klamath River during model simulations, the Project Supply from UKL is limited to 390 TAF when the above Project Supply calculation results in values greater than 390 TAF. Historic Project irrigation delivery and Lost River return flows were analyzed for the water-year 1981 through 2011 time period and a Project Supply of 390 TAF plus return flows from the Lost River system always exceeded the historic irrigation demand for each respective historic year. Therefore, a Project Supply of 390 TAF from UKL is a full irrigation supply for the Project when combined with Lost River return flows. Limiting the Project Supply for modeling purposes was required to accurately simulate the effects of the Project on UKL and the Klamath River since modeling a Project Supply greater than 390 TAF would result in greater impacts to UKL and the Klamath River than what is expected during the period of this consultation and/or what was historically observed. In addition, during model development, it was found that when the UKL Supply exceeds 1,300 TAF, the [UKL Supply minus EWA_River] equation results in a Project Supply less than 390 TAF. This situation typically occurs in wetter than average years. Therefore, when the UKL Supply is greater than or equal to 1,300 TAF, the Project Supply will be established at 390 TAF.

Any portion of contributing flows from the Lost River system not used for Project purposes will be returned to the Klamath River and considered part of the Keno Reservoir accretions, which do not count against the EWA. In the event that Reclamation determines the Project does not (or is not expected to) use all of the Project Supply, a portion of this excess volume can be made available to LKNWR for use beginning as early as August, with the majority of the remaining water available between October and November. LKNWR can also receive water, which is not part of the Project Supply, from UKL starting in June of each year. This is discussed in greater detail below.

Monthly distribution patterns were developed to simulate the delivery of the Project Supply for the Proposed Action modeling exercise. These distribution patterns were developed by analyzing historical demand patterns and taking the average percent distribution for each month. It is unlikely that real-time implementation of the Proposed Action will result in these same distribution patterns. The actual distribution of the Project Supply is heavily dependent upon current hydrologic and meteorologic conditions and will vary from year to year, but is within both the historic and modeled range.

Similar to the fall/winter period, distribution of the EWA during the spring/summer operational approach uses the Williamson River as a hydrologic indicator to determine the releases from UKL at LRD. Releases at LRD during spring/summer also take into account accretions, UKL fill rate, water released for flood control, the amount of EWA that needs to be reserved for the base flow period (June through September), and the amount of EWA already used.

This approach produces LRD releases that will, when combined with accretions, produce flows at Keno Dam that echo the relative shape and magnitude of Williamson River flows. Further, it keeps LRD releases on track to use the EWA without releasing too much water early in the spring/summer time period. In addition, when spill or adherence to a minimum flow requirement causes releases that are not proportional to the Williamson River flows, the release for the next time step is adjusted, restoring the proper proportionality.

There may be some circumstances where it is desirable or necessary to implement minor deviations from this formulaic approach to EWA distribution. Real-time hydrologic conditions, such as high flow events or emergency situations, may warrant the need to deviate from this formulaic approach. In addition, there may be specific ecologic objectives that water resource managers may want to address that can only be achieved by deviating from the formulaic approach to EWA distribution. Any time a deviation from the formulaic approach occurs, either by necessity or to address a specific ecologic objective, or if it is determined that the formulaic approach results in conditions that are not consistent with the intent of the Proposed Action, the process detailed in Section 4.3.4. Implementing Environmental Water Account Management will be followed. However, the formulaic approach for EWA distribution that was developed for implementation of the Proposed Action was designed to take the key ecologic objectives for UKL and the Klamath River into consideration. Therefore, Reclamation anticipates that implementation of the formulaic approach will address the key ecologic objectives for UKL and the Klamath River, and frequent deviations from this approach are not expected to be necessary. Any proposed significant deviations from the formulaic approach to EWA distribution must remain consistent with the analyses performed by USFWS and NMFS during this consultation.

The terms used in the equations below are described in greater detail below the following equations as well as in Appendix 4A.

$$\begin{aligned}\text{March through May LRD release} \\ &= \text{Fill\_rate\_ratio\_spring} * \text{Will\_prop\_cum} * (\text{EWA\_River} - \text{EWA\_reserve} \\ &- \text{EWAuseddv}_{-1}) - \text{C1\_EXC}_{-1} - \text{Net\_LK\_accrete}_{-1}\end{aligned}$$

During the March through May time period, the EWA_reserve volume is subtracted from EWA_River, with the intent of retaining this water for subsequent use during the summer. However, no volume is effectively reserved when UKL is spilling, or when releases at LRD are being made to meet minimum target flows at IGD. Also, in most years UKL still needs to retain a substantial volume of inflow in order to fill during the spring, so the Fill_rate_ratio_spring variable is designed to keep UKL on an appropriate trajectory. However, its influence decreases steadily as UKL fills. Reducing releases on the ascending limb of the UKL hydrograph functions to increase releases on the descending limb. This coincides with the onset of intensifying agricultural diversions that reduce Williamson River flows during May and June. In this way, the Fill_rate_ratio_spring simultaneously functions to help fill UKL and to redistribute water to produce a more normative hydrograph in the Klamath River.

$$\begin{aligned}\text{June LRD Release} \\ &= \text{Will\_prop\_cum} * (\text{EWA\_River} - 0.5 \\ &* \text{EWA\_reserve} - \text{EWAuseddv}_{-1}) - \text{C1\_EXC}_{-1} - \text{Net\_LK\_accrete}_{-1}\end{aligned}$$

In June, filling UKL is no longer a concern, so the Fill_rate_ratio_spring variable is dropped. Since June marks the transition into the base flow period in most years, only half of the EWA_reserve volume is subtracted from EWA_River.

$$\text{July through September LRD Release} = \min\left(\text{Link\_release\_forIGmax}, \frac{\text{EWA\_remain\_JulSep}}{\text{daysinmonth}}\right)$$

Releases in July through September are comprised of either the average daily release for the monthly EWA volumes established by the EWA_remain_JulSep variable, or the Link_release_forIGmax variable, whichever is smaller. When Link_release_forIGmax is the smallest, the difference in volume is accumulated and carried over into the October through November period.

The following are descriptions of the terms used in the equations above.

"Fill_rate_ratio_spring" is a proportion expressing the relative progress of filling UKL by the end of May.

"Will_prop_cum" is yesterday's flow volume in the Williamson River as a proportion of the predicted Williamson River volume from today through September 30th. Said another way, it is yesterday's Williamson River volume as a proportion of the expected volume to come.

"EWA_River" is the EWA volume that is determined on the 1st of each month for March through June using the most current UKL Supply value.

"EWA_reserve" is a portion of the EWA that is reserved from use during the spring and retained for use during the June through September base flow period. The reserved volume is based on the EWA volume.

"EWAuseddv_{-1}" is a cumulative variable which begins on March 1, and adds the daily increment of flow released as part of the EWA account.

"C1_EXC_{-1}" are flood control releases from Link River Dam.

"$\text{Net\_LK\_accrete}_{-1}$" are the net accretions from Link River Dam to IGD.

"IG_max" is a maximum flow target at IGD during July through September. In the event that calculations for Link River Dam releases would cause the flows at IGD to exceed IG_max, the volume that would exceed IG_max is not released at Link River Dam, and is instead banked for subsequent use during the October through November period. IG_max varies by month and by the magnitude of EWA_River.

"Link_release_forIGmax" is the approximate release from Link River Dam necessary to produce the "IG_max" flow at IGD

"EWA_remain_JulSep" is the current remaining EWA for the July through September period.

In October and November, there is overlap between the spring/summer and fall/winter operation because Area 1 and/or LKNWR will divert a portion of the spring/summer Project Supply during these months, and some of the EWA can be carried over from the preceding spring/summer period for distribution during October and November. Therefore, the spring/summer and fall/winter diversion accounts must be kept separate during the overlap period. The process for accounting for EWA releases, as well as Project and LKNWR deliveries, is described in Section 4.3.4., Implementing Environmental Water Account Management.

Flood control releases occur any time UKL would exceed the allowable flood control elevation under normal operations criteria. During the irrigation season, these releases typically occur March through May during average to wet years, and can occur in any year depending on the rate of snow melt, fall and winter inflow, and carry over storage in UKL. When Reclamation makes releases for flood control, they are counted against the EWA, with the exception outlined below, and are therefore factored into future EWA releases. In some cases, the flood control releases can be so large that the remaining EWA volume would not be considered adequate to provide acceptable habitat in the Klamath River for ESA-listed species throughout the remainder of the spring/summer season.

In order to protect against this scenario, a measure was added to ensure that the remaining EWA is adequate to accommodate the fish habitat needs in the Klamath River through the remainder of the spring/summer period. Reclamation will consider this protection whenever the total flood control releases from LRD have exceeded 22 percent of the total EWA by June 1st. This measure ensures a certain volume of remaining EWA each month according to the following criteria:

1. If the total flood control releases that have occurred by June 1 exceed 22 percent of the EWA, then the remaining EWA is reset to 25 percent of the total June 1st EWA.

2. If the total flood control releases that have occurred by July 1 exceed 22 percent of the EWA (as calculated on June 1), then the remaining EWA is reset to 18 percent of the total EWA.

3. If the total flood control releases that have occurred by August 1 exceed 22 percent of the EWA (as calculated on June 1), then the remaining EWA is reset to 13 percent of the total EWA.

4. If the total flood control releases that have occurred by September 1 exceed 22 percent of the EWA (as calculated on June 1), then the remaining EWA is reset to 7 percent of the total EWA.

The usage (timing and short-term delivery volumes) of the Project Supply will be managed real-time and will depend on current hydrologic conditions. A portion of any expected undelivered Project Supply can be allotted to LKNWR. LKNWR deliveries will be managed in close coordination with Project deliveries to ensure the total Project Supply is not exceeded. Details regarding the management and accounting of the EWA and Project Supply are discussed further in 4.3.4., Implementing Environmental Water Account Management. Table 4-9 summarizes the output values for the Proposed Action model run.

Reclamation proposes to provide flows to the Klamath River in late August or early September to support the Yurok Tribal Boat Dance Ceremony. The volume of water required to support the ceremony will vary depending on hydrologic conditions at the time the ceremony is conducted. The ceremony is held during even-numbered years. The volume of water required for the ceremony is estimated to be between 2 and 4 TAF depending on hydrologic conditions at the time of the ceremony. This volume of water will not count against the EWA.

For additional details regarding the spring/summer operational process, *see* Figure 4-9, Schematic of Spring/Summer EWA, Project Supply, and UKL Reserve; and Figure 4-10, Spring/Summer operations management overview flow chart; as well as Appendix 4A-1 Model Documentation.

As previously mentioned, water supplies can be made available to LKNWR during the spring/summer period from June through November. October and November are outside of the spring/summer period, however spring/summer Project deliveries, as well as deliveries to LKNWR, continue into October and November. During the spring/summer period the LKNWR deliveries are determined by a combination of Project Supply and UKL elevation conditions.

LKNWR can receive water through two different ways during the spring/summer period. LKNWR can receive a portion of the Project Supply if it is determined that the Project will not use the entire Project Supply, or LKNWR can get water that is not part of the Project Supply when UKL elevations are above certain thresholds and the Project Supply is at 390 TAF. Water can only be provided from either the Project Supply or from UKL on any given day. The two ways that LKNWR can receive water are described further below. Receiving spring/summer water deliveries during the months of October and November doesn't preclude Area 2 or LKNWR from also receiving fall/winter deliveries in October and November.

Water that is not part of the Project Supply can be provided to LKNWR from June through November when certain conditions are met. When the elevation of UKL exceeds the threshold values listed in Table 4-8 below and the Project Supply for the irrigation season is at 390 TAF, then LKNWR can receive up to the "max delivery" listed in the table below. When the Project Supply is at 390 TAF, the current elevation of UKL will be evaluated on a daily basis to determine if the elevation exceeds the threshold elevations listed in Table 4-8. These deliveries do not count towards the Project Supply.

Table 4-8. Monthly maximum refuge delivery and Upper Klamath Lake elevation thresholds.

Month	Maximum Potential Delivery (Thousand Acre-Feet)	Upper Klamath Lake Threshold (feet)
June	0.00	4,142.5
July	3.63	4,143.0
August	5.28	4,143.0
September	5.94	4,142.5
October	6.93	4,141.5

LKNWR can also receive a portion of the Project Supply during the August through November time period. If it is determined that the Project will not use all of the Project Supply, a portion of the remaining Project Supply can be made available for LKNWR. The portion of the excess Project Supply that can be made available to LKNWR is dependent on the amount of remaining Project Supply, the date, and the elevation of UKL. These Refuge water deliveries count against the Project Supply as if the water was delivered for agricultural purposes.

During times of dry hydrologic conditions and drought, water supplies can be limited resulting in shortages to water available for delivery. LKNWR deliveries are contingent upon available water supply and deliveries cannot be made when Project shortages exist. LKNWR deliveries are not available during the spring/summer period in years when Project shortages exist.

Table 4-9. Proposed Action model summary output results.

Year	EWA Volumes by Year (Determined June 1st)	Total Volume at Iron Gate Dam Each Spring/Summer Season (March-September)	End of September UKL Elevation by Year	Project Supply by Year (March-November Determined June 1st)	Project Deliveries from UKL to A1 (March-November)	Project Deliveries from UKL to A2 (March-September)	Total Project Deliveries from UKL (March-November)	Total Project Deliveries from UKL by Water Year (October-September)	Total Project Deliveries from UKL by Irrigation Season - Year (March-February)	Total Project Deliveries from All Sources by Water Year (October-September)	Total Project Deliveries from All Sources by Irrigation Season - Year (March-February)	Total Refuge Deliveries by Water Year (October-September)	Total Refuge Deliveries by Irrigation Season - Year (March-February)	Total Refuge Deliveries by Irrigation Season (March-September)	Total Refuge Deliveries by Fall/Winter (October-February)
1981	419.2	551.5	4138.3	353.5	293.7	59.8	353.5	366.4	387.2	408.3	429.0	4.2	13.4	0.0	4.2
1982	824.3	1214.0	4140.4	390.0	245.5	43.9	289.4	341.9	328.9	410.7	394.4	40.1	68.6	26.7	13.4
1983	1100.2	1572.1	4140.3	390.0	241.3	39.4	280.7	320.2	324.1	397.8	401.8	64.7	67.7	22.8	41.9
1984	974.8	1356.3	4140.6	390.0	262.4	38.8	301.2	343.8	344.3	428.6	429.1	72.6	73.6	27.6	44.9
1985	631.8	902.3	4140.1	390.0	301.1	51.5	352.5	389.6	376.1	459.8	446.7	68.0	45.4	22.0	46.0
1986	744.8	1051.3	4139.8	390.0	304.0	50.7	354.7	375.6	377.6	444.8	447.2	45.1	42.9	21.7	23.3
1987	443.1	636.3	4139.7	365.6	305.1	60.6	365.6	374.5	408.4	431.5	468.1	21.2	9.4	0.0	21.2
1988	411.7	574.4	4138.9	337.0	277.4	57.8	335.2	387.9	375.3	435.2	422.8	9.4	17.2	0.0	9.4
1989	845.5	1139.4	4138.8	390.0	299.1	52.0	351.1	402.2	372.5	461.8	428.8	28.9	27.0	11.8	17.2
1990	385.8	573.9	4139.5	322.8	266.5	56.3	322.8	339.3	342.4	391.0	394.9	15.2	0.1	0.0	15.2
1991	320.0	511.2	4138.8	281.9	232.3	49.6	281.9	312.2	301.2	331.0	320.0	0.1	0.2	0.0	0.1
1992	320.0	443.8	4137.8	161.3	129.7	31.6	161.3	184.5	189.7	192.7	197.1	0.2	6.5	0.0	0.2
1993	701.8	1069.7	4139.6	390.0	277.4	48.3	325.7	346.9	347.0	386.9	386.8	34.9	53.2	28.4	6.5
1994	320.0	454.6	4138.2	263.3	212.8	50.5	263.3	289.0	288.1	302.1	302.1	24.8	7.2	0.0	24.8
1995	622.5	917.7	4139.4	390.0	265.5	40.3	305.8	326.5	335.6	377.6	386.3	34.4	62.3	27.2	7.2
1996	734.7	1006.4	4139.4	390.0	300.3	47.7	348.1	376.4	375.9	428.1	427.2	53.2	56.5	18.0	35.2
1997	573.2	795.4	4139.7	390.0	320.8	60.1	380.8	391.9	406.5	435.2	449.6	61.9	49.9	23.4	38.5
1998	929.9	1317.6	4140.0	390.0	253.4	29.3	282.7	326.5	313.2	405.8	392.9	56.8	67.8	30.3	26.5
1999	900.2	1415.7	4139.7	390.0	317.5	52.1	369.7	375.6	397.5	454.0	475.6	57.0	51.6	19.4	37.6
2000	643.0	858.7	4139.4	390.0	319.6	51.8	371.4	403.0	391.1	477.2	465.7	42.5	23.0	10.3	32.1
2001	363.8	494.5	4138.3	310.1	256.4	53.7	310.1	346.4	335.4	359.4	347.5	12.7	5.8	0.0	12.7
2002	428.7	622.5	4138.4	373.7	312.4	61.1	373.6	380.0	398.6	437.2	458.2	5.8	3.3	0.0	5.8
2003	442.9	632.4	4138.4	353.4	287.4	53.8	341.1	375.6	360.4	439.6	423.4	3.3	3.7	0.0	3.3
2004	430.8	628.8	4138.6	372.5	312.2	58.4	370.7	380.0	391.9	440.8	453.6	3.9	6.1	0.2	3.7
2005	393.0	586.3	4138.2	326.8	272.1	54.7	326.8	353.5	362.6	404.9	415.0	5.8	15.5	0.0	5.8
2006	819.0	1160.2	4139.0	390.0	292.2	50.2	342.4	392.8	363.3	463.7	431.1	27.3	38.6	11.9	15.5
2007	496.3	730.0	4138.8	379.4	313.2	63.4	376.6	383.3	405.3	431.9	455.7	26.8	11.2	0.0	26.8
2008	549.1	860.3	4138.8	390.0	296.7	51.0	347.7	392.1	369.4	447.3	423.1	20.4	31.4	9.2	11.2
2009	465.1	654.8	4138.8	364.7	292.8	59.9	352.7	366.7	372.0	403.2	409.0	22.2	3.7	0.0	22.2
2010	345.9	511.6	4138.9	303.6	247.7	55.2	302.9	322.7	328.4	347.6	355.5	3.7	15.6	0.0	3.7
2011	745.3	1036.2	4139.2	390.0	264.3	46.3	310.5	355.2	310.5	404.7	356.6	34.0	18.4	18.4	15.6

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4.3.2.2.3. Upper Klamath Lake Flood Release Threshold Elevations

Maximum elevation thresholds for UKL will not be exceeded during the fall/winter period to ensure adequate storage capacity remains in UKL to capture high runoff events and to avoid potential levee failure due to overfilling the lake. The flood release elevations vary for the months of January through April depending on the UKL inflow forecast, and lower flood release threshold elevations are implemented when the current UKL March through September 50 percent exceedance inflow forecast exceeds 710 TAF. This allows for a greater margin of safety when high inflows to UKL are anticipated. *See* Table 4-10 for a list of the UKL flood control elevations. The flood release threshold elevations are the same for October through December regardless of hydrologic conditions. The UKL flood control elevations are intended to be used as guidance and professional judgment will be utilized in combination with hydrologic conditions, snowpack, forecasted precipitation and other factors in the actual operation of UKL during fall/winter months to ensure the protection of UKL levees and public safety.

Figure 4-11 is a graphical depiction of the UKL flood release threshold elevations that are used in the Proposed Action model run. It should be noted that these elevations are higher than UKL averaged under historical operation and operation of UKL will be closely coordinated with PacifiCorp when approaching flood control elevations.

Table 4-10. Upper Klamath Lake flood release threshold elevations for the last day of each month under relatively dry or wet conditions.

Month	Dry Condition Elevation (Forecast ≤ 710 thousand acre-feet)	Wet Condition Elevation (Forecast >710 thousand acre-feet)
October	4141.4 feet	4141.4 feet
November	4141.6 feet	4141.6 feet
December	4141.8 feet	4141.8 feet
January	4,142.3 feet	4,142.0 feet
February	4,142.7 feet	4,142.4 feet
March	4,143.1 feet	4,142.8 feet
April	4,143.3 feet	4,143.3 feet

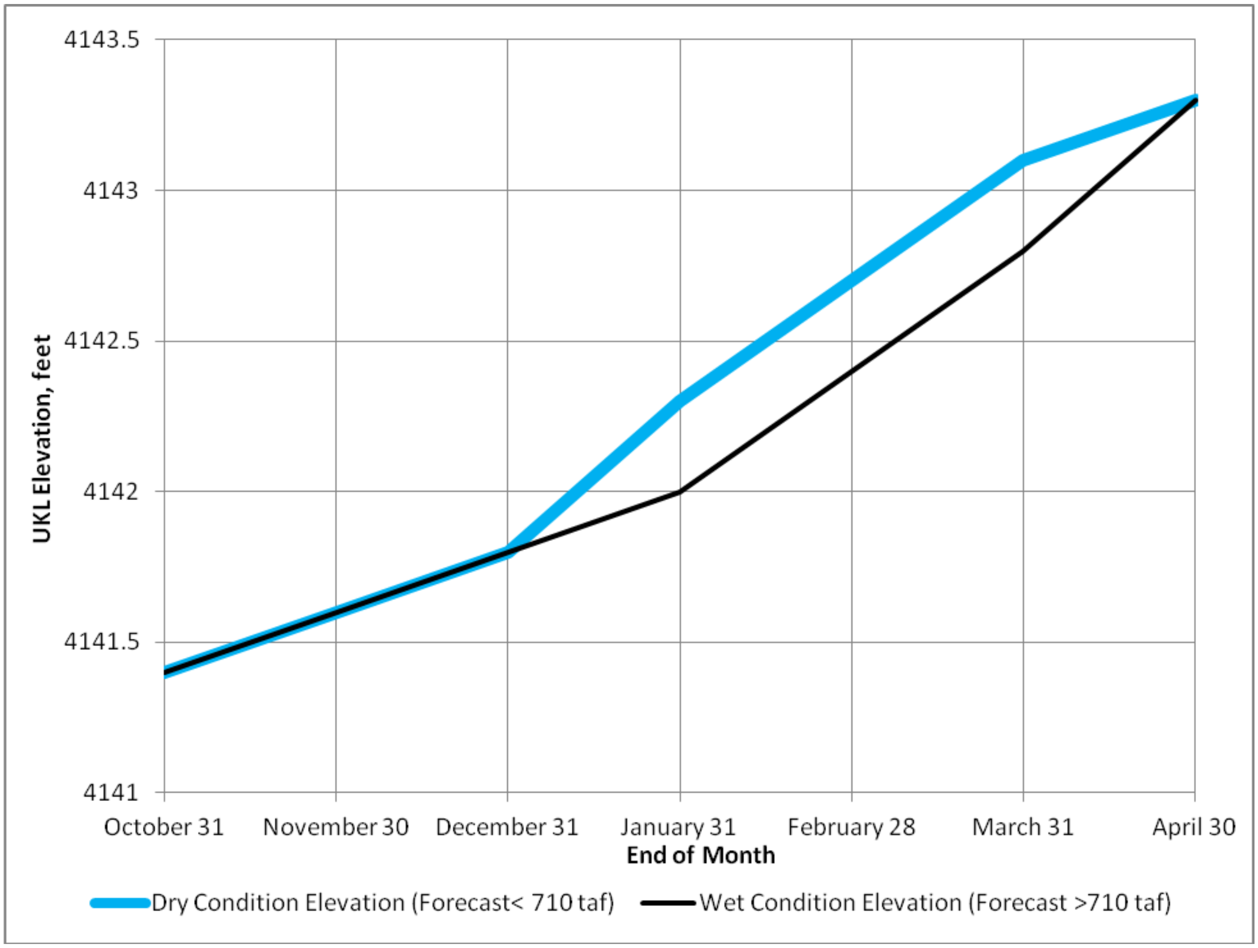

Figure 4-11. Upper Klamath Lake flood release threshold elevations for the last day of each month under relatively dry or wet conditions.

4.3.2.2.4. Ramp Down Rates at Iron Gate Dam

Ramping rates limit rapid fluctuations in streamflow downstream of dams. Reclamation proposes a ramping rate structure that varies by release rate at IGD. The ramp rates proposed below are as measured at the USGS gauging station located immediately downstream of IGD (USGS Station ID#: 11516530). IGD is owned and operated by PacifiCorp and the ramp down rates will be implemented by PacifiCorp as part of IGD operations. Reclamation will coordinate with PacifiCorp as appropriate on the implementation of the ramp down rates.

Reclamation proposes the following target ramp down rates at IGD:

- When the flow at IGD is greater than 3,000 cfs: Ramp down rates will follow the rate of decline of total net inflows into UKL combined with accretions between Keno Dam and IGD.
- When IGD flows are above 1,750 cfs but less than 3,000 cfs: Decreases in flows of 300 cfs or less per 24-hour period, and no more than 125 cfs per four-hour period.
- When IGD flows are 1,750 cfs or less: Decreases in flows of 150 cfs or less per 24-hour period, and no more than 50 cfs per two-hour period.

NMFS concluded in their 2002 BO that ramp down rates below 3,000 cfs, as outlined above, adequately reduce the risk of standing juvenile [and fry] coho salmon (p. 111, NMFS 2010). In 2010, NMFS concluded that the IGD operational ramp-down are not likely to adversely affect juvenile [and fry] coho salmon. In addition, NRC (p. 25, 2008) found the IGD ramping rates are sufficient for the protection of coho salmon.

Reclamation proposes that ramp down rates for releases above 3,000 cfs at IGD will follow the 3-day moving average of the combined inflows into UKL and accretions between Link River Dam and IGD. The 3-day moving average allows for fluctuations similar to the inherent natural variation while not requiring the extreme variability that can occur with daily changes in inflow. To the extent practicable, based upon facilities physical constraints and safety, this is intended to mimic the natural rates of change of inflows to UKL and Link River to IGD accretions. This ramp down rate structure will also ensure that UKL elevations are not drawn down to accommodate rapid, transient declines in inflow and/or accretions, lasting less than a day. Reclamation currently calculates inflow to UKL on a daily basis. In the event of a gauge failure and/or instability due to high wind events, Reclamation will use professional judgment to estimate changes in inflow. Reclamation does not anticipate such occurrences to occur frequently during rapidly changing inflow conditions and should not influence IGD ramp down rates on a regular basis.

Facility control limitations and stream gauge measurement error limit the ability to accurately manage changes in releases from IGD at a fine resolution. In addition, facility control emergencies may arise that warrant the exceedance of the proposed ramp down rates. Therefore, Reclamation recognizes that some minor variations in ramp rates will occur and all ramping rates proposed above are targets and are not intended to be strict maximum ramp rates. Reclamation expects significant exceedance of the proposed ramp rates due to facility control limitations, stream gauge error, and/or emergency situations will occur infrequently and will be minor in nature when they do occur.

The proposed ramp rates may be more stringent than necessary to prevent the stranding of ESA-listed species downstream of IGD. More flexible ramping rates should be explored by the EWA Manager in coordination with the FASTA to determine if it would be appropriate to implement more rapid targeted ramping rates when faster ramp down rates are found to be acceptable.

IGD is a PacifiCorp facility and Reclamation does not have control over the implementation of ramp down rates and operations at IGD. However, Reclamation will coordinate with PacifiCorp as appropriate to ensure that implementation of the ramp down rates is consistent with the requirement resulting from this consultation.

4.3.2.2.5. Tule Lake Sump Operations

The proposed minimum elevations for Tule Lake Sump 1A is described below. NWR deliveries are outlined in Section 4.3.2.2.6. Actual water availability and TID return flows will determine the amount of water available for Tule Lake NWR. Reclamation proposes to maintain the following minimum elevations in Tule Lake Sump 1A (Table 4-11).

Table 4-11. Minimum Sump 1A elevations (Reclamation Datum).

Time Period	Elevation
April 1 through September 30 (each year)	4,034.6 feet
October 1 through March 31 (each year)	4,034.0 feet

During excessively dry periods when the UKL Supply is inadequate to meet Project demands, it may not be possible to maintain Tule Lake Sump 1A elevations due to decreased runoff to Tule Lake Sump 1A. This condition would be outside of Reclamation's control and the proposed minimum elevations would not apply. In the event that surface water supply is estimated to be unavailable or is insufficient to maintain biological minimum elevations of Tule Lake Sump 1A (e.g., greater than 95 percent exceedance inflow years such as 1992 and 1994), Reclamation proposes to coordinate with USFWS as early as is possible to determine if relocation of adult suckers from the sumps to more permanent bodies of water within the species range is prudent. During dry winter conditions, Reclamation will initiate discussions with USFWS to determine the best course of action, including the likelihood of a sucker relocation effort from Tule Lake. If Reclamation and USFWS deem it necessary to relocate suckers from Tule Lake during these discussions, Reclamation, in coordination with the USFWS and Refuges, will develop a proposal that Reclamation will employ to relocate suckers from the Tule Lake sumps before seasonally stressful conditions develop. The proposal will describe methods for capture and transport of fish, release sites, fish handling techniques, and the appropriate level of effort expected to relocate suckers (*See* Appendix 4B for example).

4.3.2.2.6. Refuge Deliveries

Tule Lake and Lower Klamath NWRs receive water via Project facilities. Specific delivery of water for Tule Lake NWR has not historically occurred, because it has always received an adequate supply of water from agricultural drainage and runoff from precipitation. Higher than normal elevations within Tule Lake NWR are minimized by pumping off excess return flows and runoff through Pumping Plant D.

LKNWR receives water deliveries from the Klamath River via Ady Canal and Tule Lake via Pumping Plant D, in addition to receiving water from precipitation and runoff. Historic deliveries to LKNWR are summarized in Appendix 4A-4. Annual deliveries to LKNWR are dependent upon available water supply in UKL. The pattern of deliveries to LKNWR has changed in recent years due to the significant increases in power costs associated with pumping. These cost increases have caused TID to minimize pumping from Tule Lake to LKNWR through D Pumping Plant, requiring LKNWR to become increasingly dependent on deliveries from the Klamath River.

LKNWR can receive a portion of the unused Project Supply. A portion of any expected undelivered Project Supply can be made available for delivery to LKNWR for use beginning as early as August, with the majority of the remaining water being available in October and November. In addition, LKNWR can receive water from UKL that is not part of the Project

Supply, during the spring/summer period. During the fall/winter period, LKNWR will receive a portion of the UKL inflow when inflows exceed the minimum LRD release. For additional details regarding LKNWR deliveries, see the descriptions of fall/winter and spring/summer operations above.

4.3.2.2.7. Operation of the East Side of the Klamath Project

The East Side of the Project consists of two main storage reservoir facilities including Clear Lake and Gerber reservoirs. These two facilities are used to store seasonal runoff to meet irrigation needs of the East Side and to prevent flooding in and around Tule Lake. The irrigation water supplies from Clear Lake and Gerber principally serve LVID, HID, and private Warren Act contract lands. However, these supplies can be delivered to other Project lands. Return flows, accretions, and additions from Bonanza Big Spring supplement a portion of the Project being served through the Lost River system.

Irrigation on the East Side is managed to minimize any flows passing Harpold Dam, an HID facility. Excess water past Harpold Dam is utilized by irrigators or discharged to the LRDC which may either service the West Side of the Project or be released to the Klamath River.

Irrigation water supplies released from Clear Lake Reservoir primarily serve the lands to the west of the Lost River and are primarily diverted into the West Canal through headworks located at Malone Dam on the Lost River approximately 12 miles below Clear Lake. Only irrigation water supply releases are made from Clear Lake Dam unless required by an emergency situation, such as excess stored volume threatening the integrity of the dam.

Irrigation water supplies released from Gerber Reservoir, for delivery to lands to the east of the Lost River, are diverted into the North Canal through a small diversion structure on Miller Creek approximately six miles downstream of Gerber Dam. The North Canal then carries the irrigation water to lands within LVID. During the irrigation season, no water is released into Miller Creek below the structure; however, return flows from irrigation of adjacent lands and dam leakage provide some inflow. When irrigation releases are not occurring stop logs in the structure are removed, allowing free passage of flow down Miller Creek to the Lost River.

Reclamation proposes to operate the East Side of the Project as described below.

Clear Lake Reservoir Operations

Under the Proposed Action, Clear Lake Reservoir is expected to provide irrigation water supplies necessary to meet demand, which is expected to be near the long-term average of approximately 34,000 AF annually throughout the period covered by this BA. This water supply is generally used during April 15 through September of each year. The outlet at Clear Lake is generally opened on April 15 and closed on October 1. The typical outflow release rate during irrigation season is approximately 120 cfs with a typical maximum irrigation release outflow of approximately 170 cfs. Table 4-12 summarizes releases from Clear Lake Reservoir by month.

Table 4-12. Summary of 1986-2009 Clear Lake Reservoir releases (thousand acre-feet).

	April	May	June	July	August	September	October
Minimum	0.00	0.06	3.98	1.80	0.00	0.00	0.00
Median	0.23	5.49	7.14	7.82	7.66	5.66	0.00
Average	3.29	6.25	7.34	8.00	7.60	5.70	0.05
Maximum	31.27	29.20	16.32	15.73	18.68	27.44	0.42

Available water supply from Clear Lake Dam and Reservoir is estimated annually using a seasonal forecasting model (*See* Appendix 4A-5, Gerber and Clear Lake Water Supply Forecast Models). The model allows Reclamation to estimate available water supplies and provide insight on appropriate deliveries that will ensure elevations greater than the end of September minimum lake elevation, while taking into account the NRCS inflow forecast, typical delivery patterns, seepage, and evaporation. Flow changes during the irrigation season are dictated by the needs of LVID, HID, and other contracted private users along the Lost River. Table 4-13 below lists the end of September minimum proposed elevation for Clear Lake Reservoir.

Table 4-13. Minimum Clear Lake Reservoir end of September elevation (Reclamation Datum).

Water Body	Elevation (feet)
Clear Lake Reservoir	4,520.6

Gerber Reservoir Operations

Under the Proposed Action, Gerber Reservoir is expected to provide irrigation water supplies that are necessary to meet a demand expected to be near the long-term average of approximately 35,000 acre feet annually, throughout the period covered by this BA. This water supply is generally used during April 15 through September each year. The outlet of Gerber Reservoir is generally opened on April 15 and closed on October 1. The typical outflow release rate during irrigation season is approximately 120 cfs with a typical maximum irrigation release outflow of approximately 170 cfs. Table 4-14 summarizes releases from Gerber Reservoir by month.

Table 4-14. Summary of 1986-2011 Gerber Reservoir releases (thousand acre-feet).

	April	May	June	July	August	September	October
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Median	0.21	5.47	6.81	8.00	7.67	6.24	0.02
Average	1.70	4.68	6.45	7.57	7.01	5.77	0.08
Maximum	17.03	7.85	8.63	8.94	8.35	7.34	0.80

Historically, approximately two cfs of water was bypassed and released into the Miller Creek channel during the winter months to prevent a valve in the dam from freezing. This bypass typically occurred from November until the beginning of the following irrigation season. However, recently the discharge has been increased to approximately five cfs. The purpose for this bypass and release is to assist in ensuring that ESA-listed species are not stranded in pools below the dam during low flow periods and/or ensure water quality is maintained if suckers are present. Reclamation intends to continue the five cfs bypasses from Gerber Reservoir as part of its operations.

Available water supply from Gerber Dam and Reservoir is estimated annually with a seasonal forecasting model (*See* Appendix 4A-5, Gerber and Clear Lake Water Supply Forecast Models). The model allows Reclamation to estimate available water supplies and provide appropriate deliveries that will ensure elevations greater than the established *end of September* minimum lake elevation while taking into account the NRCS inflow forecast, typical delivery patterns, seepage, and evaporation. Flow changes during the irrigation season are dictated by the needs of LVID, HID, and other contracted private users along the Lost River. Table 4-15 below lists the end of September minimum proposed elevation for Gerber Reservoir.

Table 4-15. Minimum Gerber Reservoir end of September elevation (Reclamation Datum).

Water Body	Elevation (feet)
Gerber Reservoir	4,798.1

4.3.3. Element Three

Perform the O&M activities necessary to maintain Klamath Project facilities to ensure proper long-term function and operation.

This section outlines the O&M activities that are performed on Reclamation's various features within the Project. These activities have been on-going throughout the history of the Project and have been implicitly included in previous consultations with the USFWS on Project operations (*See* Part 2, Consultation History). No new maintenance activities are being proposed, rather these are only included in detail in this consultation to provide a more complete, explicit description of Project maintenance activities so that the potential effects of these actions on listed species can be more specifically analyzed. Reclamation has attempted to include all maintenance activities necessary to maintain Project facilities and ensure proper long-term functioning and operation. Reclamation also recognizes that this is not an exhaustive list and that there may be items that were inadvertently omitted. However, Reclamation believes that any omitted activities are similar in scope and are not outside the effects analyzed for the activities included in the following sections.

O&M activities are carried out either by Reclamation or the appropriate irrigation district according to whether the specific facility is a reserved or transferred work, respectively. Operation of non-federal facilities by non-federal parties is not included as part of this BA as a section 7 consultation is focused on the actions of federal agencies.

4.3.3.1. Dams and Reservoirs

4.3.3.1.1. Exercising of Dam Gates

The gates at Gerber, Clear Lake, Link River, and Lost River Diversion dams and the A-Canal, Ady Canal, and LRDC head gates are exercised bi-annually, before and after each irrigation season to be sure they properly operate. The approximate dates the gates are exercised are March to April 15 and October 15 to November 30, and potentially in conjunction with any emergency or unscheduled repairs. The need for unscheduled repairs is identified through site visits. Once identified, the repair need is documented and scheduled. Exercising gates takes anywhere from 10 to 30 minutes depending on the facility. The gates at Gerber, Link River, and Lost River Diversion dams' gates are opened and water is discharged during the exercising process. Additional information that describes associated maintenance activities performed when exercising gates at specific facilities is included as follows:

1. Link River Dam is operated by PacifiCorp who does not schedule when exercising the gate occurs. The dam is operated continuously due to the flows required from UKL to Link River. As such, the gates are considered exercised whenever full travel of the gates is achieved. A Review of Operations and Maintenance inspection should be performed every six years.

2. Clear Lake Dam gate exercise activities include exercising both the emergency gate and the operation gate. Depending on water conditions, some water may be allowed to discharge in order to allow for sediment flushing. Flushing requires a release of flows that must be at or below 200 cfs for approximately 30 minutes. This activity occurs once a year generally between March and April and is contingent on Clear Lake Reservoir surface water level elevations.

4.3.3.1.2. Stilling Well Maintenance

Gage maintenance is required at various project facilities to ensure accurate measurement of flows. Gage maintenance generally includes sediment removal from the stilling well, replacement of faulty equipment, modification and/or relocation of structural components, and/or full replacement of the structure, as necessary. Reclamation estimates that every 5 to 10 years, one structure is replaced. Stilling wells are cleaned once a year, during the irrigation season which typically runs from April 1 through October 15.

4.3.3.1.3. Other Maintenance

Boat ramps and associated access areas at all reservoirs must be maintained, as necessary, in order to perform all weather boating access to carry out activities associated with O&M of the Project. If the boat ramp is gravel it should be maintained on a five-year cycle. If the structure is concrete it should be maintained on a 10-year cycle. Maintenance can include grading, geotextile fabric placement, and gravel augmentation/concrete placement depending on boat launch type. Reclamation does not perform maintenance of boat ramps on a time schedule, but rather as needed.

Dam conduits associated with irrigation facilities are replaced on an as needed basis and typically have an average lifespan of 30 years. To determine if replacement is necessary activities may include land based observation and/or deployment of divers. Divers are deployed at Clear Lake Reservoir, Gerber Reservoir, and Link River every six years prior to the Comprehensive Facilities Review for inspection of the underwater facilities. If replacement was deemed necessary, Reclamation would evaluate the potential effects to federally-listed species and determine if additional ESA consultation would be required.

Design Operation Criteria, which outlines O&M guidelines for facilities maintenance is required at Link River Dam, Clear Lake Dam, Gerber Dam, and the LRDC gates. The Design Operation Criteria is used to develop Standard Operating Procedures for Reclamation facilities. The Standard Operating Procedures outlines the maintenance procedures, requirements, and schedule. The activities address the structural, mechanical, and electrical concerns at each respective facility. Some of the components of facilities that require maintenance are typically reviewed outside of the irrigation season and include, but are not limited to, the following:

- Trash racks - Maintained when necessary and are not on a set schedule. Trash racks are cleaned and debris removed daily and is specific to each pump as individual pumps may or may not run year round. Cleaning can take anywhere from one to eight hours.

- Fish screens (Screens at Clear Lake Reservoir are cleaned as described below).

- Concrete repair occurs frequently and as needed (not on a set time schedule.) The amount of time necessary to complete repairs to concrete depends on the size and type of patch needed.

- Gate removal and repair/replacement (performed when needed, no set time schedule.) Inspections of gates occur during the dive inspection prior to the Comprehensive Facilities Review every six years. Gates are continually visually monitored.

4.3.3.2. Canals, Laterals, and Drains

All canals, laterals, and drains are either dewatered after irrigation season (from October 15 through April 15) or have the water lowered for inspection and maintenance every six years as required as part of the Review of O&M, or on a case by case basis. Inspection includes checking the abutments, examining concrete and foundations, examining mechanical facilities, pipes, and gates. The amount of time necessary for inspection is based on size and specific facility.

Historically, dewatering of canals, laterals, and drains has included biological monitoring and (as needed) listed species salvage. This practice would continue under the current Proposed Action as described in Section 4.5.1.

The facilities are also cleaned to remove sediment and vegetation on a timeline ranging from annually to every 20 years. Inspections of all facilities take place on an annual basis. Inspections occur year round or as concerns are raised by Project patrons. Cleaning the facilities may include removing sand bars in canals, silt from drains, or material filling the facilities. Cleaning takes place year round on an as needed basis. Animal burrows that may be impeding the facilities are dug up and compacted in order to repair them. Trees that are deemed to interrupt operations of facilities (and meet criteria outlined in the O&M guidelines) and/or pose a safety threat to the structural integrity of the facilities are removed and the ground returned to as close to previous conditions as practicable.

All gates, valves, and equipment associated with the facilities are to be exercised bi-annually before and after the April 1 through October 15 irrigation season. Any pipes located on dams or in reservoirs are replaced when needed, and have an average lifespan of 30 years. Reclamation O&M staff replace approximately 10 sections of pipe per year and attempt to perform this maintenance activity when the canals are dry. Additional information that describes associated maintenance activities performed when exercising gates at specific facilities are included as follows:

1. A Canal headgates include six gates that need to be checked. The A Canal headgates are only operated and exercised when the fish screens are in place. If the breakaway screens were to fail the A Canal would still be operating until the screen is put back into place. This allows for uninterrupted operation at A Canal in the event that a screen needs to be replaced to their previous position. Screens typically break once or twice a year (during normal operation) and KID is notified through alarm and the screens are repaired at the earliest time practicable.

2. The A Canal headgates are typically exercised in the spring (February through March timeframe) and fall (October through November timeframe). This activity occurs when the bulkheads are in place and the A Canal is drained and empty.

3. The LRDC diagonal gates and banks should be inspected every six years. Review of O&M inspections alternate every six years and take place anywhere from October 15 through March 31. This inspection would require drawdown of the LRDC. The drawdown of the LRDC would leave enough water to ensure that fish were not stranded during this activity. The appropriate levels are coordinated by O&M staff and Reclamation fish biologists. Biological monitoring would be incorporated, and if necessary, flows would be increased for fish protection.

4. The Ady Canal headgates are exercised annually. This activity includes closing and opening the gates and this activity typically occurs in the July to September timeframe. All debris is also removed once a year, generally some time during the June through September timeframe.

4.3.3.3. Fish Screen Maintenance

The A Canal fish screens have automatic screen cleaners. Cleaning is triggered by timing or head difference. When cleaned on a timer the timing intervals are set at 12 hours, but can be changed at (KID) operator’s discretion. For a period defined by hours or on a continuous basis.

Fish screens at Clear Lake Headwork’s are cleaned periodically when 6 to12 inches of head differential between forebay one to two is encountered. The need for cleaning the fish screen is dictated by water quality and lake elevation and varies from year to year. For instance, in some years like 2009 the screen was cleaned every other day beginning around the end of June/first part of July until it was shut off. Whereas in 2011 no cleaning took place during irrigation season, however, the screens were cleaned prior to the irrigation season. During irrigation season the head differential never exceeded 0.3 feet. There is an extra set of fish screens that the O&M crew uses during the cleaning process. The extra fish screen is lowered in place behind the first set of screens so that no fish will be allowed to pass. The primary screens are then lifted and cleaned and then placed behind the second pair of screens in the lineup. This process is continued until all screens are cleaned. This process can take up to 10 hours. Upon completion, the remaining set is stored away until the next cleaning which is anytime there is a head difference of 0.5 feet. During flood releases (when Clear Lake elevations are 4,543.0 feet or above) fish screens would not be in place.

4.3.3.4. Fish Ladder Maintenance

Link River Dam fish ladder gate exercise activities include exercising both the head gate and the attraction flow gate which includes closing and opening the gates. This activity occurs twice annually and generally occurs in the February/March timeframe and again in the November/December timeframe. The amount of time necessary for the gates to be exercised is no longer than 15 minutes. This activity includes biological monitoring by Reclamation staff biologists.

4.3.3.5. Roads and Dikes

All roads and dikes are mowed, as necessary from April through October). Pesticides and Herbicides are also used on Reclamation managed lands, primarily canal rights-of-way to control noxious weeds. This activity typically occurs annually. The activity of pesticide spraying occurs generally from February through October (in compliance with the Pesticide Use Plan) and is applied according to the label. Vegetation control occurs on facilities where necessary, throughout the year. Techniques used to control noxious weeds may include cultural, physical, and chemical methodologies for aquatic and terrestrial vegetation. The effects of these activities have been evaluated in previous section 7 consultations and incidental take coverage was provided in the USFWS's Biological Opinions 1-7-95-F-26 and 1-10-07-F-0056 dated February 9, 1995 and May 31, 2007, respectively. In both BOs, the USFWS determined that the maintenance action of pesticide application would not jeopardize the continued existence of Lost River and shortnose suckers. The products used for this maintenance activity are still being used to minimize take and are in compliance with current Integrated Pest Management Plans required by the Reclamation Manual's Directive and Standard ENV 01-01. At this time, there have been no changes to the action.

4.3.3.6. Pumping Facilities

All pumping plants are monitored yearly by visual evaluation. Dive inspections occur every six years according to the Review of O&M inspection. This activity would include dewatering of the adjacent facility and installation of coffer dams. Dive inspections and dewatering of the facilities typically occurs in the August to December timeframe. Biological monitoring occurs daily during the dewatering of the facility and has historically been, and will continue to be, incorporated into maintenance activities to ensure the protection of fish, as necessary.

All pumps are greased, oil checked, cleaned, and exercised monthly if they are not in regular use. Pumps used for irrigation are maintained daily during the irrigation season. Drainage pumps would be maintained and operated on a daily basis, year round. Pumps are greased and oiled according to the pump manufacturer's specifications. Excess grease and oil is removed and cleaned. When oil is being changed oil spill kits are kept on site and used, as necessary.

4.3.4. Implementing Environmental Water Account Management

The purpose of Environmental Water Management is to effectively and efficiently utilize a broad range of technical expertise under the coordination of an EWA Manager to recommend and implement Environmental Water Account flow releases to meet ecological objectives for coho salmon (and other species) in the Klamath River while balancing the needs of listed suckers in Upper Klamath Lake, should it be decided that deviation from the formulaic approach previously described will provide greater ecologic benefits. There are many potential organization structures and management processes in use that could be used for implementing Environmental Water Management. The Environmental Water Management organization structure and process was developed to satisfy the following principles:

- Reclamation, acting under the authority of the Secretary of the Interior, will ultimately be responsible for Environmental Water Management on the Klamath River and UKL, and all flow decisions on the Klamath River (the proposed Environmental Water Management structure and process does not relinquish this Secretarial responsibility).

- Reclamation, as the Secretary's designee, is responsible for evaluating whether flow management recommendations are consistent with flood control, public safety, and operational constraints.

- Klamath River flow releases and UKL storage management will be guided by a combination of prescriptive releases (minimums) and real-time hydrologic conditions. However, in an effort to enhance the ecological benefits of water management, this draft Environmental Water Management approach is anticipated to provide flexibility to optimize water use.

- Identifying clear roles and responsibilities of all participants in the process.

- Having a single person responsible in the Science group for synthesizing and recommending flow management actions to the management group (i.e., Science group advises a flow management group, thereby avoiding strict voting or consensus conflicts in the Science group).

4.3.4.1 Organization Structure

This real-time EWA management approach will require significant coordination between Reclamation and other stakeholders. A formal well thought-out organization structure should be developed to outline a coordination process and ensure successful implementation of real-time EWA management. Reclamation identified this need and has coordinated with various stakeholders throughout the Klamath River watershed to develop a Draft Flow Scheduling Guidelines (Guidelines) document that is intended to provide guidance on how to implement EWA Management to optimize the ecologic benefit to aquatic species. The overall approach is to provide river and lake managers with the best available science-based flow management recommendations by creating a technical group responsible for making science-based flow recommendations to achieve ecological management objectives. This could be accomplished by forming a technical team (science) to develop flow management recommendations, reviewed and adjusted (if needed) by a management team (regulatory and policy), and approved and implemented by Reclamation. Having clear boundaries between the Science and Policy groups, but with substantial information flow between the two, should result in better flow management recommendations and more informed flow management decisions, which should result in more rapid and efficient achievement of ecological objectives within the Klamath River watershed. Several proposed groups and the associated roles and responsibilities of each group are described below. As stated above, the Guidelines document is in draft form and the organizational structure is conceptual in nature. Reclamation proposes to further develop and adopt the Guidelines document and formal structure for EWA management in coordination with USFWS, NMFS, and appropriate stakeholders within one year of implementation of the Proposed Action. Reclamation used this draft Guidelines document to develop a potential organizational structure that is discussed below.

4.3.4.1.1. Environmental Water Account (EWA) Manager

Group decision-making, particularly in a science group, can be challenging. Therefore, an EWA Manager will be hired by Reclamation to manage a FASTA Team, integrate and synthesize technical recommendations from individual FASTA Team members, and provide flow management recommendations (rapidly if needed) to the Klamath Flow Management Group and Klamath Basin Area Office (KBAO) Area Manager. The primary role of the EWA Manager is to coordinate with the FASTA in a near real-time manner to determine how to manage the EWA to best meet the needs of coho salmon in the Klamath River while balancing the needs of listed suckers in UKL. The EWA Manager will be hired, funded, and employed by Reclamation, and be responsible for providing information and recommendations to the Klamath Flow Management Group. Reclamation will coordinate with the Klamath Flow Management Group to identify appropriate performance criteria for use in assessing the performance of the EWA Manager. The EWA Manager should have a full time technical staff person under their supervision to assist with analyses and other tasks in a timely manner, particularly during the spring period. Responsibilities of the EWA Manager may include:

- Coordinate and manage meetings and activities of the FASTA Team members, but not supervising FASTA Team members (that responsibility would remain with the respective agency or tribe of that member).

- Develop a seasonal flow management strategies and priorities in coordination with the FASTA, and forward to Klamath Flow Management Group and KBAO Area Manager.

- Coordinate with entities monitoring fisheries, hydrologic, water quality, meteorological, and other indicators, and use real-time observations to evaluate whether real-time deviations from the formulaic approach to EWA distribution are needed.

- Submit additional in-season updates on flow management recommendations when a deviation in the formulaic approach to EWA distribution is warranted to the Klamath Flow Management Group and KBAO Area Manager on an as-needed basis, including minority opinions from FASTA Team members (if requested by FASTA Team members).

- Develop a weekly accounting of EWA and Project Supply used to date.
- Convene and manage FASTA Team meetings, agenda, tasks, timelines, decision-making points, products, etc.
- Coordinate with PacifiCorp as needed (up to multiple times per week) to translate Link Dam releases to Keno Dam and Iron Gate Dam releases.
- Prepare annual flow management report, including performance, accounting, accomplishments, challenges, additional monitoring needs, and recommended refinements to Flow Management Plan.
- Submit information to Science Advisory Board as needed.

The EWA Manager should consider technical input from FASTA Team members, as well as legal and regulatory requirements, when recommending flows that deviate from the formulaic approach to EWA distribution, but will not be required to follow all FASTA Team input. The role of the EWA Manager should be to synthesize technical input from FASTA Team members on flow management that best meets ecological management objectives, consider ecological tradeoffs from different technical inputs from FASTA Team members, satisfies regulatory/legal requirements and operational constraints, and makes flow management recommendations that best meet ecological objectives based on these considerations. While not required, the EWA Manager should consider objectively articulating minority opinions from FASTA Team members when conveying flow management recommendations to the Klamath Flow Management Group, including rationale for deviating from FASTA Team input, to provide transparency and build trust in the flow management recommendation process.

4.3.4.1.2. Flow Account Scheduling Technical Advisory (FASTA) Team

The purpose of the FASTA Team is to assess and incorporate real-time fisheries, hydrological, meteorological, and other data sources to provide technical input and advice to assist the EWA Manager when considering making science-based flow management recommendations that deviate from the formulaic approach to EWA distribution. The FASTA Team should be comprised of technical experts of agencies, tribes, and other appropriate stakeholders with experience and understanding of the Klamath River watershed, the Klamath Project, the Proposed Action, and managing flows for ecological purposes. Participants in the FASTA Team need to be technical specialists that are focused on meaningful participation and providing guidance to the EWA Manager, and contribute towards timely implementation of the flow recommendation process. The FASTA Team members should avoid policy issues; if policy issues arise, the EWA Manager should assist the FASTA Team members with addressing policy issues, and/or the FASTA Team members can convey those policy issues to their representatives on the Klamath Flow Management Group (i.e., the FASTA Team should focus on technical issues rather than policy issues).

The roles and responsibilities of the FASTA Team may include advising the EWA Manager on annual flow management strategies and ecologic objectives, providing technical analysis to support flow management recommendations, assisting with annual report preparation, and reviewing, evaluating, and integrating hydrological and ecological data for the Klamath River to inform flow management. A more comprehensive list of FASTA roles and responsibilities will be further developed in coordination with USFWS, NMFS, and appropriate stakeholders.

4.3.4.1.3. Klamath Flow Management Group

There are a variety of potential decision making structures and participant lists that could be developed, which is outside the scope of this document. Therefore, we use the generic term "Klamath Flow Management Group" to identify this group, and participation roster could include the following participants who have flow management responsibility in the Klamath Basin:

- Bureau of Reclamation
- California Department of Fish and Game
- USFWS
- Hoopa Valley Tribe
- Karuk Tribe
- Klamath Tribe
- Oregon Department of Fish and Wildlife
- NMFS
- Yurok Tribe

Because these participants are state, federal, and tribal governmental agencies, the Klamath Flow Management Group would not require a Federal Advisory Committee Act charter. The primary objective with the Klamath Flow Management Group is that flow management recommendations will come from the EWA Manager for the Klamath Flow Management Group to act upon, and forward to Reclamation for evaluation and implementation. Roles and responsibilities could include assigning FASTA Team members, providing input and guidance to the EWA Manager and FASTA Team members, reviewing, revising, and approving flow management priorities, and reviewing, modifying, and approving flow management recommendations. A more comprehensive list of roles and responsibilities of the Klamath Flow Management Group will be further developed in coordination with USFWS, NMFS, and appropriate stakeholders.

4.3.4.1.4. Reclamation

Reclamation will be responsible for flow management in the Klamath River watershed for portions of the Klamath River under the influence of the Klamath Project. Reclamation and KBAO Area Manager, upon receiving flow management recommendations from the EWA Manager and/or Flow Management Group, will:

1. Evaluate whether the flow recommendations are feasible given Bureau of Reclamation infrastructure and operations, public safety, flood control, and other operational constraints;

2. Evaluate whether the flow recommendations comply with applicable state and federal law;

3. Evaluate whether the flow recommendations are consistent and comply with the Proposed Action and BO (e.g., improves ecologic conditions for ESA-listed species and does not create adverse effects greater than analyzed by USFWS and NMFS); and

4. Coordinate with PacifiCorp to ensure that the flow recommendations are feasible given downstream PacifiCorp infrastructure and operations.

If the flow recommendations meet the above criteria, then Reclamation shall implement the flow recommendations in a timely manner. Reclamation will be responsible for implementing the flow recommendations, coordinating with PacifiCorp, issuing public safety notices, and any other coordination required to implement the recommendations in a timely manner.

4.3.4.1.5. Science Advisory Board

Independent scientific review of large restoration programs can be an important component to long-term implementation success and it may be desirable to develop a Science Advisory Board as part of the EWA Management organizational structure. There are two places where an independent Science Advisory Board could provide valuable input: 1) to the FASTA Team and EWA Manager to help improve the technical rigor of the science being used to develop annual flow management strategies and recommendations, and 2) to the Klamath Flow Management Group to help improve how the technical-based flow management strategies are being implemented (provided they do not stray into policy or regulatory issues that is the purview of the Klamath Flow Management Group). The Science Advisory Board should focus on broad technical implementation of the project rather than specific science details that should be addressed by discipline-specific review panels. The Science Advisory Board members should have an appointment that is long enough that they retain substantial institutional knowledge, but not so long that they become invested in the program (i.e., 4 to 5 years) and potentially diminishing their independent perspective. The EWA Manager and Klamath Flow Management Group should work collaboratively to define the specific responsibilities of the Science Advisory Board, if the Klamath Flow Management Group decides to form a Science Advisory Board.

Science Advisory Boards can add complexity to a program, and the roles and responsibilities of the Board would need to be considered carefully to ensure that there is a net benefit from their participation. A process for selecting the Science Advisory Board will also need to be developed. One option would be for the EWA Manager to recommend a process, discuss with Klamath Flow Management Group, and then oversee recruitment and selection/appointment process. The EWA Manager could manage the Science Advisory Board, but the Klamath Flow Management Group would be responsible for appointments.

4.3.4.1.6. Government-to-Government

Tribal governments will continue to exercise their legal rights, coordination, and consultation with the federal government via Government-to-Government meetings with Reclamation, USFWS, and NMFS. Tribal governments include the Yurok Tribe, Klamath Tribe, Karuk Tribe, and Hoopa Valley Tribe. Government-to-Government meetings will be held as needed.

4.3.4.1.7. Public and Third Parties

It may be desirable to allow the Public and Third Parties opportunities to provide technical and policy input to the flow management process via the Klamath Flow Management Group and Bureau of Reclamation. Technical input received would be provided to the EWA Manager, who will provide this technical input to the FASTA Team as needed. Participants include, but are not limited to, the following:

- General public
- Non-governmental organizations
- Agricultural interests
- PacifiCorp
- Recreational and fishing interests

Input can be provided during public meetings of the Klamath Flow Management Group, or directly to the Bureau of Reclamation.

4.3.4.2. EWA Management Process

As described in Section 4.2.2, EWA volumes will be determined by the total estimated UKL Supply, which is the sum of the current UKL storage and the NRCS inflow forecast to UKL. Initial 50 percent exceedance UKL inflow forecasts (UKL inflow forecasts) will be used to inform the EWA Manager and the FASTA on the likely EWA volumes for the spring/summer season. These EWA volumes will be distributed according to the formulaic approach defined in the Proposed Action Section above. UKL inflow forecasts for March 1, April 1, and May 1 will be used to determine and adjust EWA volumes. The EWA volume calculated from the June 1 UKL inflow forecast is the final EWA volume for the year. EWA and agricultural/refuge supply water volumes will adjust by month from March through May, with supplies finalized on June 1 for the June 1 through September 30 period. The calculated EWA water volumes for each time period will be used by the EWA Manager and FASTA to track the formulaic distribution of the EWA.

In some situations it may be desirable to deviate from the formulaic distribution of EWA water. These situations can include relatively minor deviations in magnitude or duration from the formulaic approach to address urgent ecologic concerns such as to alleviate fish disease or die offs, poor water quality events, fish entrainment, fish dispersal and/or migration, and other ecologic concerns that may arise during the spring/summer season. In addition to the aforementioned minor deviations from the formulaic distribution of EWA water, it may be desirable to implement flow regimes to address specific ecologic objectives that would result in relatively large deviations from the formulaic distribution of EWA. However, any recommended deviation from the EWA distribution formula, small or large, must be intended to result in improved ecologic conditions for ESA-listed species and cannot create adverse effects greater than analyzed by USFWS and NMFS during the course of this consultation. Also, it's important to note that the Guidelines document that will outline the process for deviating from the EWA distribution formula is not yet fully developed and will need to be completed prior to implementing any significant deviations from the formulaic approach to EWA distribution.

After September 30, IGD flow releases are no longer dependent on the EWA water volume, but instead depend on the inflows to UKL from the Williamson River. It is important to note that some EWA water can be carried over into the October through November period and can contribute to increased flows in October and November. The EWA Manager and the FASTA will provide flow recommendations for the distribution of any EWA volume carried over into the October and November time period. No truing up of forecasted inflow volumes versus actual inflow volumes at end of the water year will occur; the last UKL inflow forecast (June 1) will be the last inflow estimate.

There are many factors and considerations that need to be taken into account when considering developing flow regimes to address specific ecologic objectives. The development of this process should be a collaborative effort and a more detailed procedure for deviating from the formulaic distribution of EWA water will need to be further developed in coordination with USFWS, NMFS, and appropriate stakeholders.

4.3.4.2.1. River and Lake Management Objectives

The broad operational priorities for the Klamath River watershed are 1) ESA compliance and 2) meet contractual obligations. Other goals for EWA management include meeting or exceeding IGD target flows, meeting or exceeding UKL target elevations, providing natural flow variability in the Klamath River, and providing natural lake elevation variability in UKL. In addition, Reclamation also provides water to the National Wildlife Refuges when ESA and contractual obligations have been met. Management of the EWA will be done following the formulaic approach outlined in the previous spring/summer operations section, but could also be deviated from temporarily in a real-time manner to achieve greater ecological benefits; however, there are some minimum flow releases and lake elevations that should always be maintained when considering real-time water management adjustments. The EWA Manager and the FASTA will collaboratively identify specific ecologic objectives for UKL and the Klamath River to assist in guiding any flow recommendations that would deviate from the formulaic distribution of EWA water. Once fully developed, these ecologic objectives would be considered by the FASTA and EWA Manager as flow recommendations are prepared.

4.3.4.2.2. Performance Criteria

Performance criteria should be developed based on the ecological management objectives, EWA volumes, and hydrologic targets. The identified performance criteria will be evaluated using the best available scientific data for UKL and the Klamath River. Additional scientific data needs will likely be identified during the performance criteria evaluation process. These additional data needs should be recognized and prioritized by the EWA Manager and the FASTA, such that the most critical data needs can be satisfied should additional resources or funding become available. These criteria should guide an *Accomplishments and Challenges* section in the annual report. Some performance criteria will require considerable time to evaluate (e.g., flow and lake exceedance targets), while others can be determined on a daily time step (daily flow targets below IGD). The performance criteria should be based on management objectives, and be prioritized based on their linkage to flow management recommendations. The Flow Management Plan will propose and refine performance criteria specific to space and time, and several factors will need to be considered in the Flow Management Plan. The development of a Flow Management Plan is discussed further in the Refining the Environmental Water Management process section below. The performance criteria and factors for consideration will need to be developed by the EWA Manager and the FASTA.

It’s important to note that evaluating these performance measures will require consideration of measurement accuracy (is it a big difference or within the error in our measurements), correlation with Klamath River watershed flow management control (is it controlled by flow management or natural variability), and potential remedial measures for future years.

4.3.4.2.3. Refining the Environmental Water Management Process

Most large-scale water management programs develop a flow management plan at the initial stages of the project, but these plans cannot anticipate all the details, constraints, unknowns, and technical issues that will arise in the future. Therefore, a Flow Management Plan should be developed and revised using an adaptive management approach that builds from the Environmental Water Management process described here for the Proposed Action. Then, a process to periodically consider revisions are needed (an evolving document). The following review and update schedule is recommended:

- Develop Flow Management Plan based on the Proposed Action following the completion of formal consultation.

- Review Flow Management Plan at end of first year of implementation, EWA manager recommend adjustments to Flow Management Plan, and revise based on input from Klamath Flow Management Group and KBAO Area Manager.

- Thereafter, review and potentially update on a 2-year review cycle to ensure that review and refinements will occur, but at a time scale that is reasonable.

The EWA Manager, in consultation with the FASTA Team, should initiate the review, prepare recommendations (if any) on revisions to the Flow Management Plan as part of the annual reporting process, and submit to the Klamath Flow Management Group and KBAO Area Manager for review. Recommended changes, if any, should be included in the EWA Manager annual report. The Klamath Flow Management Group should consider whether to solicit input from the Science Advisory Board and/or public and third parties. The Klamath Flow Management Group, in consultation with the regulatory agencies and KBAO Area Manager, should revise and/or adopt the recommendations. Once adopted, then the EWA Manager would modify the Flow Management Plan.

4.3.4.2.4. Reporting

In consultation with the FASTA, the EWA Manager will be responsible for reporting on several aspects of EWA water management. First, an annual report should be prepared prior to the spring/summer season that summarizes broad strategies and priorities for the year based on the previous year's fisheries conditions (e.g., salmon escapement, sucker production), experimental needs, and preliminary inflow forecasts (e.g., is it a wetter or a drier water year). The EWA Manager and the FASTA will also need to prepare reports to accompany recommendations for minor deviations from the EWA distribution formula. The annual report could also be expanded upon to include any proposed flow recommendations to address specific ecologic objectives for the March through September period that would result in large deviations from the formulaic approach to EWA distribution. In addition, an end of year annual report should be prepared by the EWA Manager and the FASTA that, at a minimum, summarizes the hydrologic evolution of the water year, UKL elevation and storage, flow accounting for EWA, Project Supply, and refuge deliveries, accomplishments, challenges, and information needs for the following year, and recommended changes to the Flow Management Plan. This list of reporting requirements will need to be expanded upon, as additional reporting needs are likely to be identified as the EWA Management process is further developed during the first year of implementation.

4.3.4.3. EWA Management Key Considerations

In addition to the river and lake management objectives identified in Section 4.3.4.2.1., the EWA Manager and the FASTA will have to assess a number of key considerations when proposing in-season adjustments to address specific ecologic objectives. Some of these factors are considered "hard constraints", such as ESA considerations, physical constraints on facilities, and protection of life and property, while others are considered "soft constraints", such as certain ecological management objectives. Below is a list of key considerations that the EWA Manager and FASTA should take into consideration when making flow schedule or any in-season flow schedule adjustment recommendations.

4.3.4.3.1. Risk and/or Error Management

NRCS inflow forecasts are not exact and are a source of variability within the system. The UKL elevations and the timing and magnitude of EWA water releases may be influenced by either increases or decreases in the UKL inflow forecasts. In addition to the variability in forecasts, actual inflows into UKL, which indicate water availability and indicate in real-time what supplies are available, also experience a range of variability. Both apply risk to Klamath River and UKL ecological objectives, as well as irrigation and refuge uses. Therefore, this risk is reduced by using the updated NRCS 50 percent exceedance UKL inflow forecasts as they become available during the January through June period. The UKL Reserve, Project Supply, refuge flows, and EWA volumes will be revised based on these evolving UKL inflow forecasts, distributing hydrologic risk amongst the various users during the March 1 through September 30 period. Because there are no additional inflow forecasts after June 1, and no truing up of the forecasted inflows versus actual inflows at the end of the water year, there is some risk of inflow error during the June 1 through September 30 period. However, this time period is after the majority of runoff from the upper basin has occurred, and the runoff during this period can be fairly accurately estimated, so the risk of significant error is lower. After June 1, any error in the UKL inflow forecast (+ or -) will be imposed on UKL storage and the resulting elevation.

Because the EWA Manager and FASTA have some flexibility in real-time flow recommendations, there is another source of risk associated with this flexibility. For example, if there is a real-time need to increase flows for a short duration that exceed the magnitude of flows in the planned river operations, the EWA Manager could be in the position of recommending more flow than what is in the EWA account. Therefore, to minimize this risk, if the EWA Manager recommends flows that are greater than the planned river flows at a certain time of the year, the recommendation should also include a clear description of the effects of the flow adjustment and a commensurate decrease in the planned river flows later in the spring/summer period to balance the EWA account. These real-time flow recommendations must be consistent with BO rules, operational constraints, and public safety.

4.3.4.3.2. Hydrologic and Ecological Management Issues

Several key hydrologic and ecological considerations have been identified that need to be taken into account when making recommendations regarding EWA implementation, including:

Actual UKL elevations. The EWA flow schedule will result in a specific pattern of UKL elevations each year. However, the actual elevations may differ from that pattern and result in conditions that vary depending on actual UKL net inflows, climate, and in-season flow schedule adjustments.

Reliability of estimated accretions downstream of Link River Dam. The accretions between Link River Dam and IGD vary over time and the estimated accretions utilized when developing any in-season flow schedule adjustment recommendation, may differ from actual observed accretions, which may warrant an in-season flow adjustment at Link River Dam.

Actual IGD releases. IGD releases are the result of Link River Dam releases, accretions to the Klamath River between Link River Dam to IGD, and PacifiCorp management. Various factors that are not entirely under Reclamation's control influence the difference between Link River Dam releases and IGD flows including accretions and PacifiCorp facilities management. As a result, conditions may arise where the scheduled releases at Link River Dam may need to be either increased or decreased to support desired releases at IGD based on real-time conditions.

Release infrastructure at IGD. IGD is managed by PacifiCorp. PacifiCorp has indicated that at releases above 1,750 cfs at IGD, substantial operational changes are made in releasing flows. As a result, PacifiCorp has requested that scheduled releases avoid fluctuations above and below 1,750 cfs to the extent possible. In addition, PacifiCorp has a limited ability to make significant adjustments to IGD flows above 1,750 cfs without adequate lead time. Close coordination between the EWA Manager, Reclamation, and PacifiCorp should reduce the lead time needed for real-time flow management.

IGD Ramping Rates. Ramping rates define the maximum permissible rates for the decrease in flow from IGD and limit rapid fluctuations in streamflow and river stage downstream of IGD. The IGD ramping rates should be considered when making flow scheduling recommendations since the ramping rates will, in part, determine the amount of EWA water required to implement a given flow schedule. Ramping rates must follow the target ramp rates listed in Section 4.3.2.2.4., Ramp Down Rates at IGD.

Iron Gate fish hatchery release schedule. Releases from Iron Gate fish hatchery should be taken into consideration when the EWA Manager and the FASTA recommend flow schedule adjustments.

Klamath River water quality and water temperature. Situations may arise where the scheduled releases at Link River Dam may be adjusted in an attempt to support desired water quality or temperature conditions in the Klamath River downstream of IGD. Real-time water quality and water temperature data may be analyzed to provide additional information on the need to adjust the scheduled flows at IGD.

Sucker spawning activity. Sucker spawning appears to be related to water temperature in UKL. As a result, real-time weather can affect when spawning occurs. Changes in the scheduled EWA releases may be advisable if spawning could be affected (either positively or negatively) by the scheduled releases.

Sucker fry and juvenile movement within UKL. Entrainment of fry and juvenile suckers is a recognized issue at Link River Dam. In some situations it may be advisable to modify the scheduled EWA releases may be adjusted to reduce the flows during periods of high sucker concentrations near Link River Dam.

4.3.4.3.3. Coordination Needs with PacifiCorp

Close coordination and communication by the EWA Manager with PacifiCorp on the operation of the Klamath Hydroelectric Project will be required to efficiently implement any EWA flow schedule. If the FASTA and the EWA Manager wish to provide a Klamath River flow recommendation that deviates from the spring/summer EWA distribution formula, all available information regarding the deviation will be provided to PacifiCorp for review and comment as soon as it is available. PacifiCorp will communicate any concerns that they may have regarding the recommended flow schedule deviation and provide recommendations to resolve those concerns when appropriate. The EWA Manager will coordinate with the FASTA and the KBAO Area Manager to review PacifiCorp's concerns and recommendations, if any, and will consider modifying the flow schedule to address those concerns. Adequate lead time must be provided to PacifiCorp when implementing deviations from the EWA distribution formula. The EWA Manager will make every attempt to provide two weeks advance notice to PacifiCorp when requesting flow schedule adjustments. In some circumstances the EWA Manager may request PacifiCorp to respond in less than two weeks if the adjustment to the flow schedule is urgent due to the need to respond to real-time and/or emergency conditions that warrant rapid response (i.e., fish disease, fish die off, poor water quality, unexpected hydrologic conditions, etc.).

PacifiCorp will begin implementing flows according to the EWA distribution formula starting on March 1 of each year. Once implementation of the formulaic approach to EWA distribution is initiated, the EWA Manager will monitor IGD flows to ensure that the actual observed flows are consistent with the EWA flow schedule.

PacifiCorp's operation of the Klamath Hydroelectric Project will influence the timing and magnitude of the hydrograph downstream of IGD due to water travel time through the reservoirs and due to facilities operations. These influences are expected to be minimal since flows released from Link River Dam for the purpose of EWA, as well as Link River Dam to IGD accretions, must pass through the hydroelectric project reservoirs, which have a limited storage capacity. Due to the limited storage capacity, the hydroelectric project must pass the water through the reservoirs, and are not expected to greatly influence the timing and magnitude of IGD outflows.

On a weekly basis, the EWA Manager will coordinate/communicate with PacifiCorp to assess how the actual observed IGD flows compare to the estimated flows, and communicate any necessary minor adjustments of Link River Dam releases to PacifiCorp. During periods of rapid hydrologic change and/or during an urgent in-season flow schedule adjustment, it may be necessary to coordinate with PacifiCorp more frequently. PacifiCorp will make every attempt to follow the flow schedule as closely as possible within the operational constraints of the Klamath Hydroelectric Project facilities, based upon their responsibilities under the existing habitat conservation plan. The EWA Manager will work with Reclamation to produce a weekly accounting spreadsheet that summarizes EWA releases to date and compares how closely the actual flows match the EWA flow schedule, and make it available to the FASTA, Klamath Flow Management Group, and stakeholders. If actual flows deviate too greatly from the flow schedule, the EWA Manager may need to coordinate with PacifiCorp, the FASTA, and KBAO Area Manager to take corrective action, which may result in the need for a formal in-season deviation from the EWA distribution formula. The relative effect of deviating from the flow schedule depends on many hydrologic, climatologic, and ecologic factors, and the same amount of deviation from the flow schedule doesn't warrant the same response in all situations. For example, a deviation of 100 cfs downstream of IGD when flows are in excess of 3,000 cfs doesn't require the same consideration as a deviation of 100 cfs when IGD flows are at 900 cfs. Each instance will need to be considered on a case-by-case basis.

4.3.4.3.4. Constraints

UKL flood control elevations. Early in the March through September period, UKL has the potential to fill to a level that creates a risk for levee failure and flooding of adjacent properties. This is a "hard constraint" on elevations that may be reached and varies with the time of year and hydrologic conditions. The EWA scheduling may require rapid adjustment to reflect excessively high water conditions in UKL. The EWA Manager will take these elevations and the current elevation of UKL into consideration when scheduling EWA flows to ensure that the scheduled flows do not result in excessively high elevations in UKL.

Minimum flows at IGD. These flows represent the minimum necessary to meet the needs of critical coho salmon activities, including spawning access, spawning, juvenile movement, or smolt movement at various times of the year and under various conditions.

PacifiCorp BO and FERC Requirements. PacifiCorp has flow management requirements for their BO and FERC license, and therefore flow recommendations for the Klamath River watershed must be consistent with PacifiCorp's flow management requirements.

Physical constraints of Link River Dam. The maximum controlled release at Link River Dam is 8,800 cfs. This maximum release must be taken into consideration by the EWA Manager and the FASTA when developing the EWA flow schedule.

Minimum flows below Link River Dam. These flows represent the minimum necessary to meet the physical habitat needs of aquatic species and reduce the risk of stranding suckers in the Link River downstream of Link River Dam.

4.3.4.4. Information Needs and Modeling Tools

Implementing real-time management of EWA flow releases will require access to a variety of models, hydrologic data, meteorologic data, and biological data. The following information is anticipated to be available to the FASTA Team and EWA Manager at various times of the year:

- Meteorological forecast for upcoming 7 to 10 days.
- Runoff forecast evolution.
- Snowpack and/or precipitation index stations.
- Projected accretion between Link River Dam, Keno Dam, and IGD (return flows from Lost River Diversion Canal and Klamath Straits Drain, springs, surface runoff).
- Water temperature and streamflow index stations.
- Daily operation summary spreadsheet that documents flows through the year, including agriculture and refuge supplies, Klamath River releases, and UKL elevations (made available to FASTA Team and EWA Manager).
- UKL inflows/storage/elevations.
- Information on juvenile salmonid rearing concentrations and outmigration at various monitoring locations.
- Information on sucker larvae and juvenile reproductive success and development stage.
- Access to WRIMS model to do gaming and risk assessment for various runoff forecasts in near real-time.
- Access to water temperature model for real-time use at times of year when EWA Management has an effect on water temperatures.
- Access to daily operations model to help manage flows and evaluate implications under management (rather than historic time series approach).
- Degree day model for coho salmon emergence timing.

The above list is not intended to be a comprehensive list of information needs and future modeling tools, as additional needs are likely to be identified as the real-time management of the EWA is implemented. The EWA Manager in coordination with the FASTA Team will identify and prioritize additional information needs, such that the most critical additional information need can be satisfied should resources and/or funding become available to do so.

4.3.4.5. EWA, Project Supply, and Refuge Water Accounting

All water originating from UKL and diverted into the A Canal, LRDC, North Canal, and Ady Canal during the spring/summer period will count towards the Project Supply. Measurements for these diversions will be obtained at the point of diversion. Any flow released from Link River Dam during the spring/summer period (March through September), that is not diverted into the LRDC, North Canal, or Ady Canal, is considered an EWA release and is counted towards the

EWA. It is important to note that return flows from Project facilities (i.e., LRDC and Klamath Straits Drain) and lands adjacent to the Klamath River are considered accretions, are not counted against the EWA, and contribute to increased flow variability downstream of IGD.

Flood control releases from UKL during the spring/summer period also count towards the EWA in most instances. Flood control releases occur any time UKL would exceed the allowable flood control elevation. During the irrigation season, these releases typically occur March through May during average to wet years, but can occur in any year depending on the rate of snow melt, fall and winter inflow and carry over storage in UKL. In some cases, the flood control releases can be so large that the remaining EWA volume would not be considered adequate to provide acceptable fish habitat for the remainder of the spring/summer period. In order to protect against this scenario, a measure was added to the Proposed Action to ensure that the remaining EWA is enough to accommodate the minimum fish needs. This protection is considered and will be implemented whenever the total flood control releases have exceeded 22 percent of the total EWA from June 1 to the end of September. Refer to Appendix 4A-1, Model Documentation, and the Proposed Action section above, for additional details.

The Manager will perform weekly in-season accounting and reporting of the EWA usage as well as remaining EWA, Project deliveries, remaining Project Supply, UKL elevation, refuge deliveries, and remaining refuge allotment. This weekly accounting will track EWA usage and help ensure that the EWA is used according to the EWA distribution formula. Also, the weekly accounting will identify if too much EWA water is being used early in the season, which may result in an EWA shortage and low IGD base flows late in the season. *See* Table 4-16 below for a depiction of what the weekly accounting might look like.

Table 4-16. Depiction of accounting for the Project Supply and EWA (thousand acre-feet).

Date	UKL Supply (TAF)	EWA (TAF)	EWA Released (TAF)	EWA Remain (TAF)	Project Supply (TAF)	Project Supply Released (TAF)	Project Supply Remaining (TAF)
March 1	1,151	783	70	713	368	7	361
April 1	1,196	827	150	606	370	27	336
May 1	1,204	827	170	437	378	54	290
June 1	1,169	792	183	218	378	76	214
July 1	1,169	792	76	142	378	84	131
August 1	1,169	792	67	75	378	73	58
September 1	1,169	792	75	0	378	46	12

4.4. Water Users Mitigation Program

Authorized under Public Law 106-498, Klamath Basin Water Supply Enhancement Act; the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) as amended; Public Law 97-293, Reclamation Reform Act, Section 210; and Public Law 102-250, Reclamation States Emergency Drought Relief Act, the Water Users Mitigation Program (WUMP) is a program of feasibility studies to examine the potential capability of local stakeholders to develop, administer, and manage market-based water supplementation programs for the purpose of lessening the impacts to water users and to increase flexibility in meeting water delivery needs for fish and wildlife by reducing overall agricultural surface water demand when the Klamath Project experiences water shortages.

The WUMP is administered under a cooperative agreement, executed in 2008, between the Reclamation and the Klamath Water and Power Agency (KWAPA), a joint power, interstate, intergovernmental agency with authority in California and Oregon. KWAPA works with Reclamation, Oregon Water Resources Department, California Department of Water Resources, the Klamath Project Irrigation Districts, and others to create and manage studies related to increasing storage capacity, development of additional groundwater supplies, and other innovative means of providing additional water supplies to the Upper Klamath Basin and the Klamath Project.

The WUMP does not create, invalidate, or preempt any exception to State water law nor does it affect the management of UKL elevations or Klamath River flows, but rather operates to mitigate shortages of Project water supply and to help to meet the competing water needs of the Klamath Basin.

The WUMP will not be a tool for providing water for endangered species purposes because Reclamation proposes to first meet flows and lake levels which Reclamation believes are sufficient to avoid jeopardizing the continued existence of federally-listed species. Certain activities included in the WUMP are not within Reclamation's discretion and are undertaken by non-Reclamation parties.

4.5. Conservation Measures

The term "conservation measures" is defined as actions to benefit or promote the recovery of listed species that are included by the federal agency as an integral part of the Proposed Action. These actions will be taken by the federal agency or applicant, and serve to minimize or compensate for, project effects on the species under review. These may include actions taken prior to the initiation of consultation, or action which the federal agency or applicant have committed to complete in a BA or similar document. The conservation measures proposed assist Reclamation in best meeting the requirements under section 7 of ESA by (1) "…utilizing our authorities in furtherance of the purpose of this Act by carrying out programs for the conservation of endangered species…" and (2) avoiding actions that jeopardize the continued existence of listed species.

4.5.1. Canal Salvage

Each year at the end of irrigation season canals, laterals, and drains are dewatered. This activity includes biological monitoring in the form of fish salvage at select locations. As such, Reclamation proposes to continue the performance of fish salvage for suckers in Project canals, in cooperation with USFWS, consistent with the salvage efforts that have been occurring in Project canals since 2005. Reclamation's fish salvage efforts will focus on the A Canal forebay in front of the fish screen, C4 Canal, D1 Canal, and D3 Canal within the KID and J Canal within the TID. Other locations proposed by USFWS would be considered annually. Further, Reclamation may research alternative methods of dewatering canals, laterals, and drains which could result in less sucker presence within these facilities at the end of the irrigation season. Should a determination be made, based on this research, that fish salvage at specific locations was no longer needed or can be modified, Reclamation would coordinate with USFWS for concurrence.

4.5.2. Captive Rearing Program

Between 2000 and 2012, Reclamation has supported (carried out and/or funded) various conservation measures within the upper Klamath Basin which has resulted in significant improvements to the Baseline (including screening the A-Canal and Geary Canal, removing Chiloquin Dam, providing fish passage at Link River Dam, increasing habitat at the Williamson River Delta Preserve, seasonally salvaging suckers from canals). However, there are few, if any, other practicable options for reducing take, an effect of the Project.

As such, Reclamation proposes to support captive propagation of Lost River and shortnose suckers with the beneficial purpose and intention of increasing the number of second year juvenile suckers reaching maturity in UKL. Ultimately, the function of captive propagation would be to promote survival and recovery of the suckers populations that suffer losses from entrainment as a result of the Project or other threats. Captive propagation is already an important part of listed fish recovery efforts nation-wide, including at least three sucker species (June sucker, razorback sucker, and robust redhorse sucker).

The USFWS has implemented pilot studies in raising Lost River and shortnose suckers. Sucker larvae were collected from Lake Ewauna and the Williamson River and successfully reared in a series of tanks and holding ponds for approximately a year. Based on these studies, many aspects of Lost River and shortnose sucker captive propagation have been assessed and shown to be practicable, including rearing from eggs taken from wild-caught broodstock, rearing from wild-caught larvae, and rearing from wild-caught juveniles that were salvaged from Project canals. These efforts show that captive propagation of Lost River and shortnose suckers is feasible and could take a variety of forms, thus being flexible in terms of how it would be implemented and what the goals are.

Specifically, Reclamation proposes to support a captive propagation program by providing approximately $300,000 annually that would be used for capital and operating costs associated with the captive propagation program. Oversight of the propagation project will be provided by USFWS with input from the Klamath Sucker Recovery Program, in coordination with Reclamation. Reclamation’s support of the captive propagation program would be for the period of this consultation (April 1, 2013 – March 31, 2023). The program is intended to have a positive effect on the species. However, monitoring will determine the actual effectiveness and necessity of continuation of the program. This determination would be made through coordination between Reclamation and USFWS where alternative methods of meeting the goal and intent of this conservation measure may be identified.

4.5.3 Recovery Implementation Team Participation

The draft revised Recovery Plan for the Lost River sucker and shortnose sucker calls for the establishment of a Recovery Implementation Team (RIT), which will be led by the USFWS, to coordinate implementation of the final plan (USFWS 2011). The RIT will consist of agencies, groups, and individuals appointed by the USFWS to be responsible for participation in the implementation of the actions identified in the final revised Recovery Plan to achieve recovery for Lost River and shortnose suckers.

Reclamation intends to work with USFWS beginning in 2013, towards achieving the goals and objectives of the final revised Recovery Plan, which would include dedication of resources determined in coordination between Reclamation and USFWS.

Part 5 SPECIES STATUS FOR LOST RIVER AND SHORTNOSE SUCKERS AND COHO SALMON

The following discussion on the Status of the Species contains a level of detail beyond what is generally required for a BA. However, select elements of the Status of the Species are discussed in this BA to provide a basis for the Effects Analysis contained in Parts 7 and 8 of this document. A more thorough discussion can be found in prior ESA consultation documents (e.g., *NMFS 2010 Biological Opinion on Operation of the Klamath Project Between 2010 and 2018* and the *USFWS 2008 Biological/Conference Opinion Regarding the Effects of the U.S. Bureau of Reclamation's Proposed 10-Year Operation Plan (April 1, 2008 to March 31, 2018) for the Klamath Project and its Effects on the Endangered Lost River and Shortnose Suckers*).

5.1. Shortnose and Lost River Sucker

5.1.1. Description

Shortnose (*Chasmistes brevirostris*) and Lost River (*Deltistes luxatus*) suckers are endemic to the Upper Klamath Basin (Moyle 2002). As a member of the genus *Chasmistes*, the shortnose sucker is closely related to the cui-ui (C. c*ujus*) of Nevada, the June sucker (C. *liorus*) of Utah, and the recently extinct Snake River sucker (C. *muriei*) of Wyoming (NRC 2004). The Lost River sucker is currently the only species representative of the genus *Deltistes*. Reclamation recognizes that hybridization is common among Basin suckers (Dowling 2005, Tranah and May 2006, USFWS 2007a, 2007b). The degree of hybridization makes field identification of suckers in the Basin problematic, particularly in certain bodies of water in the Lost River drainage, such as Clear Lake and Gerber Reservoirs (Markle et al. 2005, Barry et al. 2007a, Leeseberg et al. 2007). For the purposes of life history and population descriptions at certain bodies of water throughout this document, Reclamation has attempted to compile information on only the two endangered species. For bodies of water where identification of species has proven difficult, such as the Lost River drainage (including Clear Lake and Gerber Reservoirs), this was not always possible. Thus, the reader should be aware that shortnose sucker identifications in the Lost River drainage are suspect and likely include an unknown number of misidentifications and hybrid suckers with morphological characteristics that are shared by shortnose, Lost River, and Klamath largescale suckers (*Catostomus snyderi)*.

5.1.2. Life History

Lost River and shortnose suckers are long-lived western catostomids (Buettner and Scoppettone 1990). Lost River suckers collected from the 1971 snag fishery were aged to 57 years, while Lost River and shortnose suckers from a more contemporary collection of 2001 through 2006 were aged to 40 years and 24 years, respectively (Terwilliger et al. 2010). Lost River suckers reach reproductive maturity at six to nine years of age (Perkins et al. 2000a) while reproductive maturity for female shortnose suckers may be attained as early as four years of age. Fecundity in both Lost River and shortnose suckers is variable and likely associated with the size of the individual female (Perkins et al. 2000a). Lost River suckers typically produce 44,000 to

236,000 eggs per spawning season, while female shortnose suckers produce 18,000 to 72,000 (Perkins et al. 2000a).

5.1.2.1. Larvae

The rate of embryo development is likely related to temperature, but the relatively small sucker eggs generally hatch in approximately 10 to 14 days after fertilization (Buettner and Scoppettone 1990). Developing larvae remain in the natal substrates for approximately an additional seven days before emergence. Much of the yolk sac is absorbed by the developing larvae before emergence (Buettner and Scoppettone 1990). Larvae are about a third of an inch long (7 to 9 mm) and mostly transparent with a small yolk sac (Buettner and Scoppettone 1990). Larval suckers need to begin feeding quickly before they exhaust their yolk or they will starve (Klamath Tribes 1996, Cooperman and Markle 2003). Therefore, the availability of appropriate habitat, which provides sufficient food soon after hatching, may be critical to the survival of larvae.

Larval sucker emergence from natal gravels typically occurs at night and much of the larval sucker migration from the tributaries to the lake also occurs at night (Cooperman and Markle 2003). Larval suckers exit the river current and move to nearshore shallow areas of the riverine environment during daylight (Cooperman and Markle 2003). Seasonal and nightly timing of larval drift from the tributaries is variable between natal sites (Ellsworth et al. 2008, Ellsworth et al. 2011). Early evidence suggests that larvae spend relatively little time upriver before drifting downstream to the lakes (Buettner and Scoppettone 1990, Perkins and Scoppettone 1996, Klamath Tribes 1996, Cooperman and Markle 2003). In the Williamson River, larval sucker out-migration from spawning sites begins as early as March and is generally completed by mid-July (Ellsworth et al. 2011). Recent evidence indicates that some larvae may rear to the juvenile stage in the riverine environment, as juvenile suckers have been captured in the Williamson and Sprague rivers through the summer months (Murphy and Parrish 2008, Ellsworth et al. 2009).

Larval suckers hatched at shoreline spawning areas also presumably emerge from the gravels in greater numbers at night. Larvae hatched at shoreline spawning areas in UKL may disburse southward by prevailing currents in the lake (Markle 2007). Larvae transform into juveniles at about 25 mm total length (TL) and make an ontogenetic shift toward benthic prey items (Markle and Clausen 2006). This generally occurs by mid-July (USFWS 2008a).

In UKL, larval suckers are first captured in early April during most years. Peak larval sucker catches occur during June with densities dropping to very low levels by late July (Cooperman and Markle 2000, Simon et al. 1996, 2000, 2009). Larval suckers are found throughout UKL, with highest concentrations generally near the mouth of the Williamson River, and just to the east and west of the mouth (Simon et al. 1995, 1996, 2009). Larval habitat in UKL is generally along the shoreline, in water 4 to 20 inches deep and associated with emergent aquatic vegetation (Buettner and Scoppettone 1990, Simon et al. 1995, 1996, 2009, Markle and Simon 1993, 1994, Cooperman and Markle 2000, Dunsmoor et al. 2000, Reiser et al. 2001, Cooperman 2002, Markle and Dunsmoor 2007). Larval sucker ecology and habitat use within the Lost River watershed, particularly Tule Lake, Lost River, and both Clear Lake and Gerber Reservoirs, have not been directly studied. Given the lack of direct observations, larval sucker ecology in the Lost River watershed is assumed similar to the observations from UKL, except for the use of emergent vegetation in some lake environments. Permanent emergent vegetation is generally scarce or absent along the shorelines of Clear Lake and Gerber Reservoirs (Reclamation 2002).

5.1.2.2. Young-of-the-Year (YOY) Juveniles

Larvae grow into YOY juveniles typically by midsummer. Transition from the larval to juvenile stage typically occurs at a TL of about ¾ to 1 inch (20 to 30 mm; Markle and Clauson 2006). Juveniles appear to continue to occupy shoreline habitats in UKL including both unvegetated areas and areas with emergent vegetation (Buettner and Scoppettone 1990, Simon et al. 2000, 2009, Hendrixson et al. 2007a, 2007b). Juvenile sucker habitat is generally in nearshore areas with depths less than four feet (1.2 meters [m]; Markle and Simon 1993, Reiser et al. 2001, Simon et al. 2000, Simon and Markle 2001, VanderKooi and Beulow 2003). However, juvenile suckers appear to occupy a wide range of substrate types in comparison to larvae while in these nearshore areas of UKL (Figure 5-1).

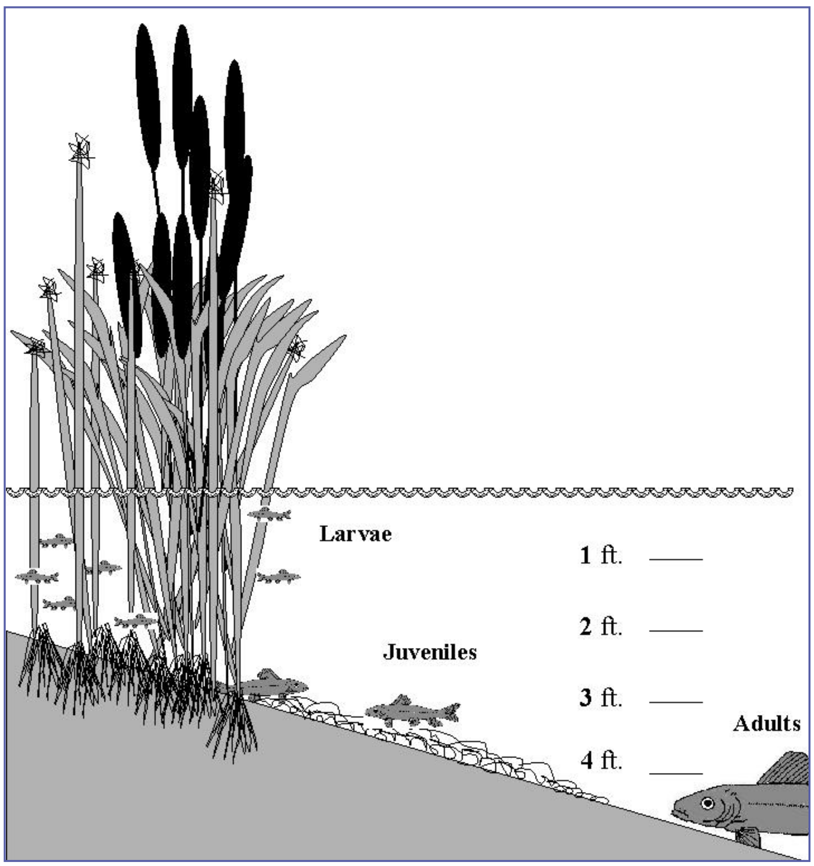

Figure 5-1. Lake habitat utilization by sucker life history stages (USFWS 2008a).

In late summer and early fall, YOY juveniles continue to occupy shoreline areas of UKL with evidence of a habitat transition into offshore areas during autumn (Terwilliger 2006). Juvenile Lost River suckers dominate offshore surveys from June throughout the summer in comparison to shortnose suckers which demonstrate an affinity for the nearshore throughout the summer (Simon et al. 2009). Juvenile sucker abundance drops dramatically from August to October in UKL (Simon and Markle 2001, Terwilliger et al. 2004, Terwilliger 2006, Simon et al. 2009, Korson et al. 2011, Korson and Kyger 2012). Possible hypotheses explaining the apparent reduced abundance of juvenile suckers include reduction of emergent vegetation habitat with reducing lake elevation (VanderKooi and Beulow 2003, Markle and Dunsmoor 2007), a shift to offshore habitat use (Terwilliger 2006), and advection from UKL including both emigration and entrainment (Markle et al. 2009).

There is evidence that YOY sucker advection from UKL into the Link River, including the east and west power canals that parallel the Link River, increases between July and October at the south end of the lake (Gutermuth et al. 1999, 2000a, 2000b, Foster and Bennetts 2006, Tyler 2007, Markle et al. 2009). The cause of advection by juvenile suckers is not currently understood. Plausible hypotheses include natural emigration, avoidance of or impairment from poor water quality events, diminished habitat in the north end of UKL which concentrates suckers in the southern end of UKL near the outlet, and entrainment (USFWS 2002, 2008a).

5.1.2.3. Older Juveniles and Adults

Whereas larval and YOY juvenile suckers primarily use shallow shoreline habitats, older juvenile and adult suckers are observed off-shore at greater depths, except when adults are spawning or seek refuge from poor water quality events in UKL. Adult suckers are found in open water areas of the lake environment during summer months, typically at depths of greater than three feet and in the northern area of UKL (Peck 2000, Banish et al. 2007, 2009).

Much of our knowledge regarding older juvenile and adult suckers is from observations of populations in UKL. Direct observations of older juvenile suckers are typically few and anecdotal in nature. In the absence of information, it is presumed that older juvenile suckers typically demonstrate behavior patterns similar to adult suckers while in the lake environment as older juvenile suckers are neither frequently encountered nor abundant during YOY juvenile studies (Burdick et al. 2008). Recent information indicates that older juvenile suckers, defined as after the first year of life and before sexual maturity, also use open water habitat along with some nearshore habitats, particularly along the western shore of UKL and around the Williamson River Delta (Burdick and VanderKooi 2010, Burdick 2012a, 2012b).

Older juvenile and adult suckers are found in open water areas of the lake environment typically at depths greater than 3.28 feet (1m) in the northern half of UKL (Peck 2000, USFWS 2002, Banish et al. 2007, 2009). During summer, adult suckers generally demonstrate a depth preference for water depth greater than the mean depth available in the area (Reiser et al. 2001, Banish et al. 2007, 2009). Recent information on adult sucker behavior in UKL indicated that each species demonstrated different depth utilization in 2005 and 2006 (Banish et al. 2007, 2009). Adult suckers were observed using water depths generally greater than 9.84 feet (3m) for Lost River suckers and greater than 6.56 feet (2m) for shortnose suckers where adequate water quality was above the species' tolerance thresholds determined by Loftus (2001); neither species was observed at water depths greater than 16.4 feet (5m; Banish et al. 2007, 2009).

During times other than midsummer, adult suckers were seasonally observed in water depths other than the former generalizations. For several weeks during June, shortnose suckers were observed in the area between the Williamson River and Agency Straits that is typified by relatively shallow water, but were never observed in water depths between zero and 3.28 feet (zero and 1m; Banish et al. 2007, 2009). Adults of both species tended to congregate in or near Pelican Bay during 2005 and 2006 at a variety of depths when water quality conditions, particularly DO, in the north end of the lake became stressful (Banish et al. 2007, 2009). Adult suckers selected depths less than 6.56 feet (2m) only when water quality conditions deteriorated in midsummer and during fall as they redistributed in the lake (Banish et al. 2007, 2009).

Cover is a primary habitat feature required by fish. For lake suckers that primarily occupy open water, depth and turbidity can provide needed cover. In streams, while deeper pools provide some cover, additional cover is provided by instream and overhanging structure (Buettner and Scoppettone 1991, Perkins and Scoppettone 1996). Adults, and probably older juveniles, of both species are bottom-oriented, consistently staying within one foot of the bottom (Buettner and Scoppettone 1991, Reiser et al. 2001). Adults rarely enter water shallower than 3.28 feet (1 m; Reiser et al. 2001, Banish et al. 2007, 2009), except possibly to spawn at night or to avoid deteriorating water quality conditions. In Tule Lake, where much of the lake is shallower than 3.28 feet (1m), adult suckers are found primarily in the very limited areas with available habitat and depths greater than 3.28 feet (1 m; Hicks et al. 2000, Reclamation 2000).

In late spring through September, adult suckers generally occupy the northern third of UKL (Figure 5-2; Golden 1969, Bienz and Ziller 1987, Buettner and Scoppettone 1990, Peck 2000, Perkins et al. 2000a, Reiser et al. 2001, Banish et al. 2007, 2009).

Lost River suckers and shortnose suckers typically spawn at night in shallow areas with gravel substrate where eggs are broadcast or slightly buried (Bienz and Ziller 1987, Buettner and Scoppettone 1990, 1991, Klamath Tribes 1995, Perkins and Scoppettone 1996, Perkins et al. 2000a). Water depth at spawning sites has been reported as 0.33 to 2.3 feet (0.1 to 0.7m) for shortnose suckers and 0.65 to 2.6 feet (0.2 to 0.8 m) for Lost River suckers, with most spawning occurring at a depth close to 1.6 feet (0.5 m) for both species (Buettner and Scoppettone 1990). The timing of spawning migration is somewhat variable from year to year and depends on age, species, sex, and environmental conditions, most notably water temperature (Andreasen 1975, Ziller 1985, Buettner and Scoppettone 1990, Klamath Tribes 1996, Perkins and Scoppettone 1996, Markle et al. 2000, Shively et al. 2000a, BLM 2000, Barry and Scott 2007, Barry et al 2007c). Larger, older females produce substantially more eggs and therefore can contribute relatively more to recruitment than a recently matured female (USFWS 2002). However, only a small percentage of the eggs survive to become larvae. There is evidence that individuals may not spawn each year, particularly females (Perkins et al. 2000a, Hayes et al. 2002, Barry et al. 2007b).

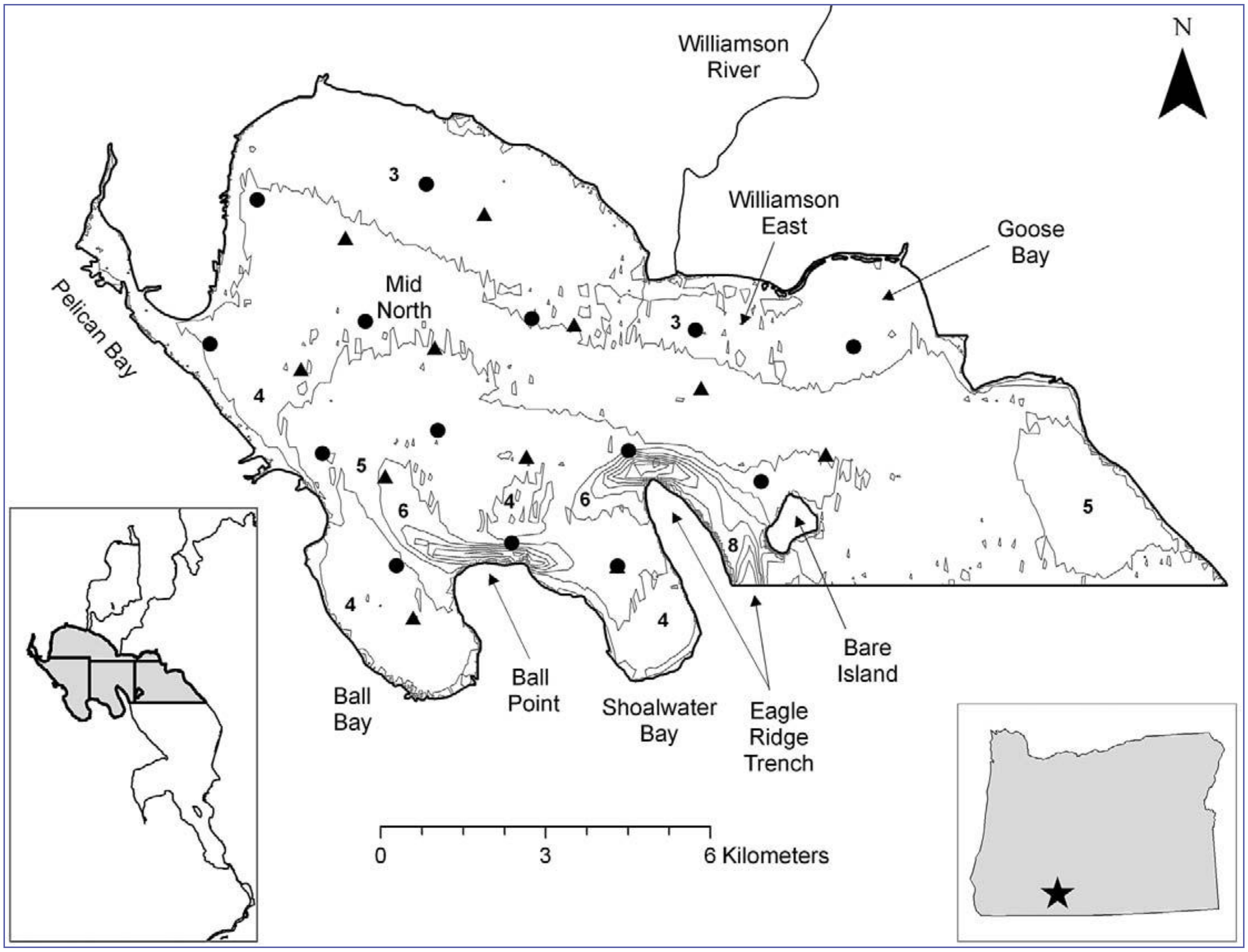

Figure 5-2. Adult Lost River and shortnose suckers utilize open water habitats in the northern area of Upper Klamath Lake during summer months. Circles and triangles indicate locations of water quality monitoring stations during the study (figure from Banish et al. 2009).

Currently, most of the stream-spawning Lost River and shortnose suckers in UKL migrate into the Williamson and Sprague Rivers to spawn during spring months. Small spawning populations of suckers may also use the Wood River (Markle and Simon 1993, Simon and Markle 1997). Lost River suckers and a small number of shortnose suckers spawn at shoreline sites of UKL, especially along the eastern shore of UKL at areas with spring influence and gravel substrate (Buettner and Scoppettone 1990, Hayes and Shively 2001, Hayes et al. 2002, 2004, Barry et al. 2007b). Presently, known spawning occurs along the shore of UKL at Sucker, Silver Building, Ouxy, and Boulder Springs, and Cinder Flats (Figure 6-1; Shively et al. 2000a, Hayes and Shively 2001, Hayes et al. 2002, 2004, Barry et al. 2007b). Stream and lake spawning populations in UKL appear to rarely exchange individuals and may be reproductively isolated (Perkins et al. 2000a, Shively et al. 2000a, Hayes and Shively 2001, Hayes et al. 2002, 2004). Suckers in the Clear Lake and Gerber Reservoir drainages spawn primarily, if not entirely, in the tributary streams (Koch and Contreras 1973, Buettner and Scoppettone 1991, Perkins and Scoppettone 1996, BLM 2000, Barry et al. 2007a, Leeseberg et al. 2007).

5.1.3. Distribution

Historically, both Lost River and shortnose suckers occurred in suitable aquatic habitats throughout the Upper Klamath Basin, with the exception of the higher elevation, cooler temperature tributaries, which are dominated by resident trout, and the upper Williamson River, which is isolated by the Williamson River Canyon (USFWS 2002). The general range of Lost River suckers and shortnose suckers had been reduced from its historic extent by the loss of major populations in Tule Lake and Lower Klamath Lake, including Sheepy Lake (USFWS 1988). At the time of listing, Lost River and shortnose suckers were reported from UKL and its tributaries, Lost River, Clear Lake Reservoir, the Klamath River, and the three larger Klamath River Reservoirs (Copco, Iron Gate, and J.C. Boyle). The current geographic ranges of Lost River and shortnose suckers have not changed substantially since they were listed. Only two additional populations of shortnose suckers and one additional population of Lost River suckers have been recognized since 1988. Each additional population occurs in isolated sections of the Lost River drainage, within the historical ranges of the species, and include an isolated population of shortnose suckers in Gerber Reservoir and a small group (limited to several hundred adults) of both species in Tule Lake (USFWS 2002). Presently, the Klamath River Reservoir populations receive individuals carried downstream from upper reaches of the river, but they are isolated from the Upper Klamath Basin by dams and show no evidence of self-sustaining reproduction (Desjardins and Markle 2000).

5.1.4. Legal Status

The Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) were federally listed as endangered throughout their entire range on July 18, 1988 (53 Federal Register [FR] 274130). Both of these species are also listed as endangered in California (1974) and Oregon (1991). In 2007, the status of each of these species was reviewed by the USFWS. It was recommended that no changes be made to the status of the shortnose sucker (USFWS 2007b). It was also recommended that Lost River sucker be downlisted to threatened (USFWS 2007a); however, recent data on population trends will likely result in a status change in the next 5-year status review (during 2012).

A draft revision of the recovery plan for these species was published by the USFWS in October 2011, and included designation of two recovery units for each species: the UKL Recovery Unit which includes individuals in UKL, its tributaries, and any of the reservoirs along the Klamath River, and the Lost River Basin Unit which includes all individuals in lakes and flowing water in this subbasin (Figure 6-1). The USFWS anticipates that draft revised recovery plan will be finalized during 2012.

5.1.5. Upper Klamath Lake Species Current Condition

UKL in Oregon probably supports the largest remaining populations of Lost River and shortnose suckers in the Klamath Basin (NRC 2004). Adult Lost River suckers in UKL appear to consist of two distinct stocks, those fish that spawn along the eastern shoreline, and fish that spawn in the Williamson and Sprague rivers (NRC 2004). Mark-recapture data has indicated that the two stocks maintain a high degree of fidelity to spawning areas and probably seldom interbreed (Hayes et al. 2002, Barry et al. 2007b). The river spawning segment of the UKL population makes a springtime spawning migration through the lower Williamson River, with most fish entering the lower Sprague River. Chiloquin Dam, identified as a partial barrier to upstream passage that prevented a portion of the spawning run from migrating further upstream into the Sprague River (Scoppettone and Vinyard 1991, USFWS 1993, NRC 2004), was removed during summer 2008. Adult sucker migrations in the Sprague River have been unimpeded since spring 2009.

Known areas of concentrated Lost River sucker spawning in the Williamson and Sprague rivers include the lower Sprague River (below the former site of Chiloquin Dam), areas of the lower Williamson River from the confluence with the Sprague River to immediately downstream of the U.S. Highway 97 bridge, and in the Beatty Gap area of the upper Sprague River (Buettner and Scoppettone 1990, Tyler et al. 2007, Ellsworth et al. 2007). Other areas in the Sprague River watershed where Lost River sucker spawning is suspected include the lower Sycan River and the Sprague River near Kamkaun Spring (Ellsworth et al. 2007).

Presently, shortnose suckers from UKL spawn in the lower Williamson and Sprague rivers (Buettner and Scoppettone 1990), principally below the site of former Chiloquin Dam (Tyler et al. 2007, Ellsworth et al. 2007). Few adult shortnose suckers are captured at the shoreline spawning areas in UKL (Hayes et al. 2002, 2004, Barry et al. 2007b). Whereas it is possible that spawning may occur in other main tributaries or small tributaries to UKL, fisheries investigations have not identified sucker populations in tributaries other than the Williamson, Sprague, and Wood rivers (Reclamation 2007).

Adult Lost River suckers in UKL have experienced a general trend for relatively good survivorship; however, they also are experiencing an extended period of little recruitment. Based on mark-recapture analysis of adult Lost River suckers in UKL, the survival of males and females from the tributary spawning and the shoreline spawning groups was high (greater than 0.9) between 1999 and 2009 with a few exceptions (Hewitt et al. 2011, Hewitt et al. 2012). Lower survival occurred for both sexes from the tributaries in 2000, for males from the shoreline areas in 2002, and for males from the tributaries in 2006. Recruitment of new individuals into either spawning population was trivial in all years between 2002 and 2007 (Hewitt et al. 2011). Over that period, the abundance of Lost River sucker males in the lakeshore spawning subpopulation declined by 44 to 53 percent and the abundance of females declined by 25 to 38 percent. Similarly, the abundance of Lost River sucker males in the tributary spawning subpopulation declined by as much as 39 percent and the abundance of females declined by as much as 33 percent (Hewitt et al. 2011). Overall, the decline of both Lost River sucker spawning groups is about 40 percent over the last decade (Hewitt et al. 2012). The declines primarily reflect a lack of recruitment of new individuals into the spawning populations, but capture-recapture estimates show Lost River suckers have experienced some years with relatively poor survival as well (Hewitt et al. 2012).

Capture-recapture analyses for shortnose suckers in UKL suggests the majority of annual survival estimates between 2001 and 2007 were high (greater than 0.8), but shortnose suckers experienced more years of low survival than either spawning group (i.e., tributary or shoreline) of Lost River suckers (Hewitt et al. 2011, 2012). The survival of both sexes for shortnose suckers was particularly low in both 2001 and 2004, and male survival also was somewhat low in 2002 and 2006. Similar to Lost River suckers, recruitment of new individuals into the spawning population was small in all years between 2001 and 2009 and was not sufficient to compensate for the adult mortality. The shortnose sucker population has declined more than either subpopulation of LRS (Hewitt et al. 2012). Since 2001, the abundance of male shortnose suckers declined by 58 to 80 percent and the abundance of females declined by 52 to 73 percent; the overall decline in abundance for shortnose sucker could be 75 percent or more (Hewitt et al. 2011, 2012). The recent declines follow abundance declines from large fish die-offs in UKL that occurred in the 1990s.

Despite relatively high survival in most years for Lost River and shortnose suckers, both species have experienced substantial declines in the abundance of spawning fish because losses from mortality have not been balanced by recruitment of new individuals (Hewitt et al. 2011, 2012). All adult sucker populations in UKL appear to be largely comprised of fish that were present in the late 1990s and early 2000s (Hewitt et al. 2011). Survival analyses show that the two species do not necessarily experience poor survival in the same years and that poor survival on an annual scale is not predictable from fish die-offs observed in the summer and fall (Hewitt et al. 2011). However, both species appear to share very little recruitment during approximately the last 20 years (Hewitt et al. 2011, 2012).

5.1.6. Clear Lake Reservoir Species Current Condition

Both Lost River and shortnose suckers reside in Clear Lake Reservoir (Figure 5-3). No studies were performed on the fish fauna of Clear Lake prior to construction of the dam in 1910. Because there is no fish passage over Clear Lake Dam, it is reasonable to assume that suckers were present in the lake prior to completion of the dam (Reclamation 2002). Spawning by both species is only known to occur in Willow Creek, a tributary to Clear Lake (USFWS 2002). Shoreline spawning by either species has not been observed in Clear Lake Reservoir. Monitoring of spawning migration in lower Willow Creek since 2004 suggests that annual run size of spawning suckers is positively correlated with stream flow (USFWS 2008a).

Populations of both species in Clear Lake Reservoir have periodically been sampled starting with Koch et al. (1975) and most recently by the USGS (Leeseberg et al. 2007, Barry et al. 2007a, Barry et al. 2009, Hewitt and Janney 2011). Data collected by Andreasen (1975) and Koch et al. (1975) suggested sucker populations in Clear Lake Reservoir were in decline. However, data from fish surveys and monitoring from 1989 through 2000 indicated that populations of both Lost River and shortnose suckers were abundant and had diverse age structures (Buettner and Scoppettone 1991, Reclamation 1994a, Scoppettone et al. 1995, USFWS 2002). More recently, data from 2004 and 2005 indicated that sucker populations were relatively abundant in Clear Lake although there was a lower frequency of larger individuals present when compared to data from the 1990s (Barry et al. 2007a, Leeseberg et al. 2007). Such a change in length frequency distribution suggests relatively good recruitment but low adult survivorship (USFWS 2002).

The most recent length frequency data indicates that Lost River suckers in Clear Lake experienced a population “turnover” in approximately 2000 where larger (and presumably older) fish died and smaller fish replaced them as dominant in the sampling efforts (Barry et al. 2009, Hewitt and Janney 2011). Through fall of 2010, this cohort remains dominant with little evidence of additional individuals recruiting into sampling gear until 2007 (Barry et al. 2009, Hewitt and Janney 2011). Based on limited sample sizes, there is evidence that many of the Lost River suckers (about 70 percent for males and 80 percent for females) that recruited in 2007 are no longer present in recent sampling efforts; however, the remaining individuals (about 29 percent males and 19 percent females) have been observed in routine sampling (Hewitt 2011, pers. comm.). The disappearance of larger individuals and relatively sparse recruitment of Lost River suckers since 2000 are based on limited observations, but do suggest recent instability within Lost River sucker populations at Clear Lake Reservoir.

Shortnose suckers also demonstrated a population turnover during the same time period based on length frequency data indicating a dominant group of smaller fish replacing larger fish in 2000 (Barry et al. 2009, Hewitt and Janney 2011). However, shortnose suckers in Clear Lake show relative routine episodes of individuals recruiting behind the dominant cohort during the early and mid-2000s based on length frequency data (Hewitt and Janney 2011). Shortnose suckers have dominated the sucker catches at Clear Lake Reservoir (Koch et al. 1975, Buettner and Scoppettone 1991, Scoppettone et al. 1995, Barry et al 2009). Evidence of both numerically dominated sucker surveys and the continued evidence of recruitment for shortnose suckers suggest relative stability for this species in Clear Lake Reservoir.

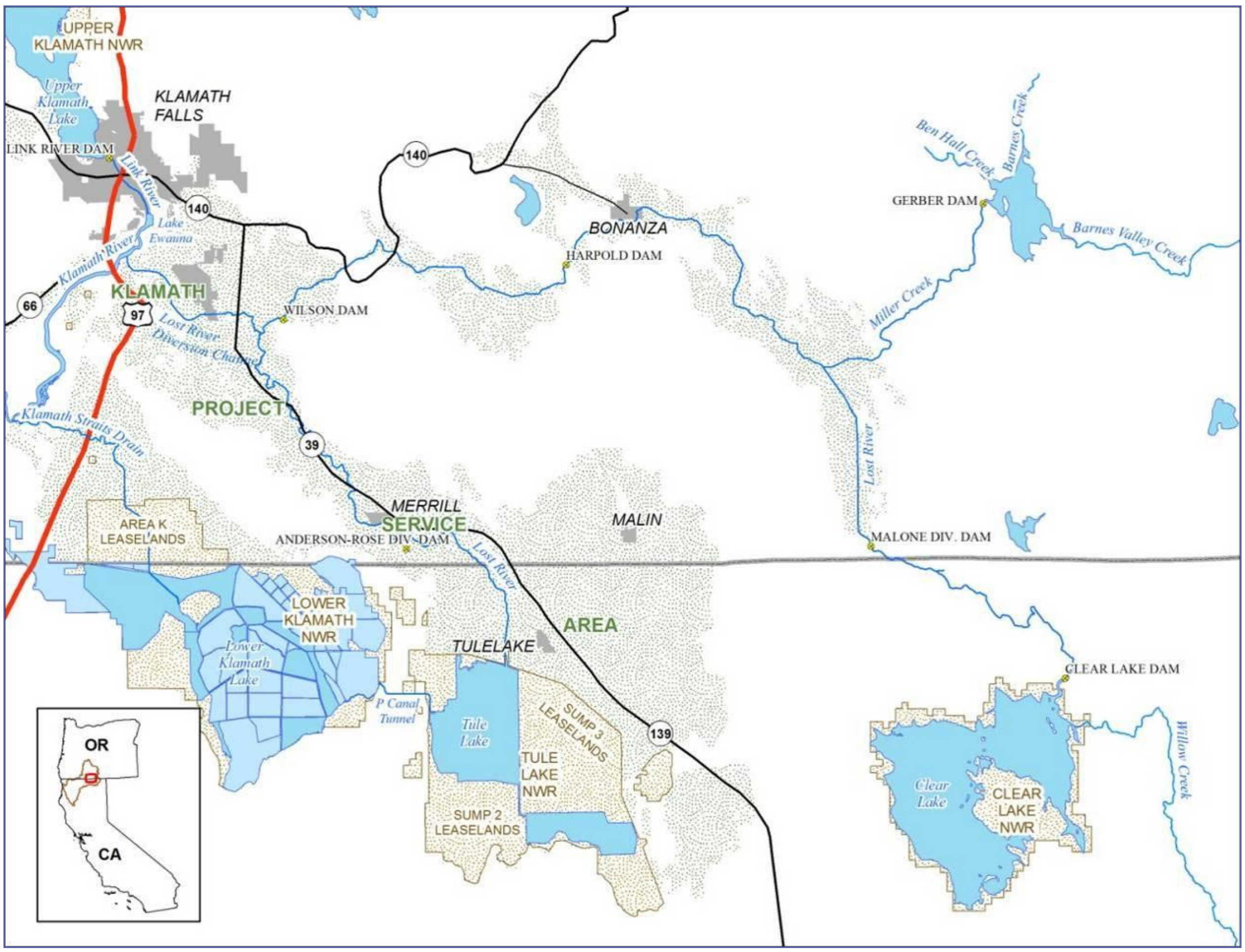

Figure 5-3. The Lost River drainage of northern California and southern Oregon and its connections to the Klamath River drainage. Project lands are shown as shaded.

5.1.7. Gerber Reservoir and Other Locations Species Current Condition

Data on other populations (i.e., Keno Reservoir, Klamath River Reservoirs, Tule Lake, Gerber Reservoir, and the Lost River proper) are extremely limited, but they suggest low numbers of individuals (Figure 5-3; Hodge and Buettner 2009, Desjardins and Markle 2000). Gerber Reservoir may be an exception to this.

Monitoring within the Gerber Reservoir watershed since 1992 has documented a substantial shortnose sucker population exhibiting multiple size classes. Recruitment in the Gerber Reservoir population of shortnose suckers appear relatively successful based on the presence of small individuals in sampling efforts at the Reservoir. While the population of shortnose suckers in Gerber Reservoir appears to have more frequent recruitment than some other populations, the problem of restricted distribution and lack of genetic connectivity with other populations still exists (USFWS 2002). Lost River suckers were not observed at Gerber Reservoir during early and recent fisheries investigations (Barry et al. 2007a, Leeseberg et al. 2007), and are likely not present in Gerber Reservoir.

Spawning at Gerber Reservoir occurs in the tributaries, particularly Ben Hall and Barnes Valley creeks (Piaskowski and Buettner 2003), and possibly Barnes Creek. Shoreline spawning has not been observed at Gerber Reservoir.2007a, Leeseberg et al. 2007). Spawning surveys in 2006 detected approximately 1,700 shortnose suckers of the nearly 2,400 that had been tagged the previous year (Barry et al. 2007a). A high degree of hybridization between shortnose suckers and Klamath largescale suckers is thought to occur in Gerber Reservoir (Markle et al. 2005). However, until the status of these fish has been resolved, the USFWS considers the Gerber sucker population to be shortnose sucker (USFWS 2008a).

Current variability in population dynamics is largely unknown, but given the relatively long life expectancy of these species, populations are generally stable over the short-term. A long life span and high fecundity enable these species to withstand unfavorable periods, and generally buffer against large fluctuations in abundance.

5.2. Southern Oregon/Northern California Coast Coho Salmon Evolutionarily Significant Unit

The NMFS listed the SONCC coho salmon ESU, which includes populations spawning from Elk River, Oregon to Mattole River, California, as a threatened species in 1997 (62 FR 24588; May 6, 1997). In 2005, NMFS reaffirmed the status of SONCC coho salmon as a threatened species and also listed three hatchery stocks as part of the ESU (70 FR 37160; June 28, 2005).

5.2.1. Description and Distribution

An adult coho salmon may measure more than two feet (60 cm) in length and can weigh up to 35 pounds (16 kilograms). However, the average weight of adult coho salmon is 8 pounds (3.6 kilograms). Coho salmon have dark metallic blue or greenish backs with silver sides and a light belly and there are small black spots on the back and upper lobe of the tail while in the ocean. Coho salmon adults migrate from a marine environment into freshwater streams and rivers of their birth in order to mate (called anadromy). They spawn only once and then die (called semelparity).

Coho salmon were historically distributed throughout the North Pacific Ocean from central California to Point Hope, Alaska, through the Aleutian Islands, and from the Anadyr River, Russia, south to Hokkaido, Japan. In the past, coho salmon probably inhabited most coastal streams in Washington, Oregon, and northern and central California.

5.2.2. Life History

Although, there are other life history traits that are important to coho salmon populations (Roni et al. 2012), the predominate life history of coho salmon in the Klamath River Basin have a three-year life cycle, the first 14 to 18 months of which is spent in freshwater, after which the fish live in the ocean until they return to freshwater to spawn (NRC 2004).

5.2.2.1 Adult

For the purpose of this BA, the adult life history is separated into three components: marine rearing, freshwater migration, and spawning.

5.2.2.1.1. Marine Rearing

Marine survival during ocean rearing depends on a number of interacting factors, including the abundance of prey, density of predators, the degree of intra-specific competition (including that from hatchery fish), and fisheries (NRC 1996). The importance of these factors in turn depends on ocean conditions (NRC 2004). Even relatively small changes in local and annual fluctuations in marine water temperature can be related to changes in salmon survival rates (Downton and Miller 1998). Even more important are multi-decadal (20- to 50-year) fluctuations in ocean conditions, which can result in drastic changes in ocean productivity for extended periods of time (Hare et al. 1999, Chavez et al. 2003).

These long-term ocean patterns can further complicate analysis of specific ocean influences. El Niño–Southern Oscillation, or El Niño/La Niña–Southern Oscillation, is a quasiperiodic climate pattern that occurs across the tropical Pacific Ocean roughly every five years. The "Pacific Decadal Oscillation" is a long-lived El Niño-like pattern of Pacific climate variability. Pacific Decadal Oscillation fluctuations were most energetic in two general periodicities, one from 15 to 25 years, and the other from 50 to 70 years.[8]

Steve Johnson, Oregon Department of Fish and Wildlife, Research and Development Section, provided a presentation in 1996 in which he estimated marine survival rates for coastal coho salmon and explored possible factors that may influence marine survival (Emmett and Schiewe 1997). Marine survival of coho salmon smolts released from Fall Creek (Alsea River, Oregon), ranged from near zero to 10 percent during 1970 to 1994 (Figure 6-12). He found potential influences of ocean temperature and coastal upwelling on marine survival. In 2006, Nickelson (2006) found a similar pattern with marine survival of Klamath River Basin hatchery-produced coho salmon and therefore presumably wild coho salmon is highly variable from year to year. Nickelson (2006) estimated survival of the 1977 to 2001 Iron Gate Hatchery coho salmon ranged from 0.12 percent to 5.7 percent (Figure 6-13).

[8] Information was obtained from the The Pacific Decadal Oscillation Web site: http://jisao.washington.edu/pdo/ Accessed on October 24, 2012.

Thus marine survival has a significant impact on the number of adults returning to the Klamath River. As an example, NMFS analyzed the reasons for the poor performance of the 2004 and 2005 brood years for the Sacramento River Fall Chinook salmon (Lindley et al. 2009). The evidence pointed to ocean conditions because conditions in freshwater for these brood years were not unusual. Estimates at the entrance to the estuary showed near normal levels of abundance. Lindley et al. (2009) found that anomalous conditions in the marine environment for these brood years likely resulted in unusually poor survival. Both brood years entered the marine environment during periods of weak upwelling, warm sea surface temperatures, and low densities of prey (Lindley et al. 2009). More recently, the Pacific Fishery Management Council (PFMC) predicted a record pre-season adult Chinook salmon return for 2012. The 2012 return estimated at 1,651,800 Klamath River fall Chinook salmon (Table I-1 in PFMC 2012) by the PFMC is based on evidence suggesting that good ocean survival conditions have allowed these fish to thrive.

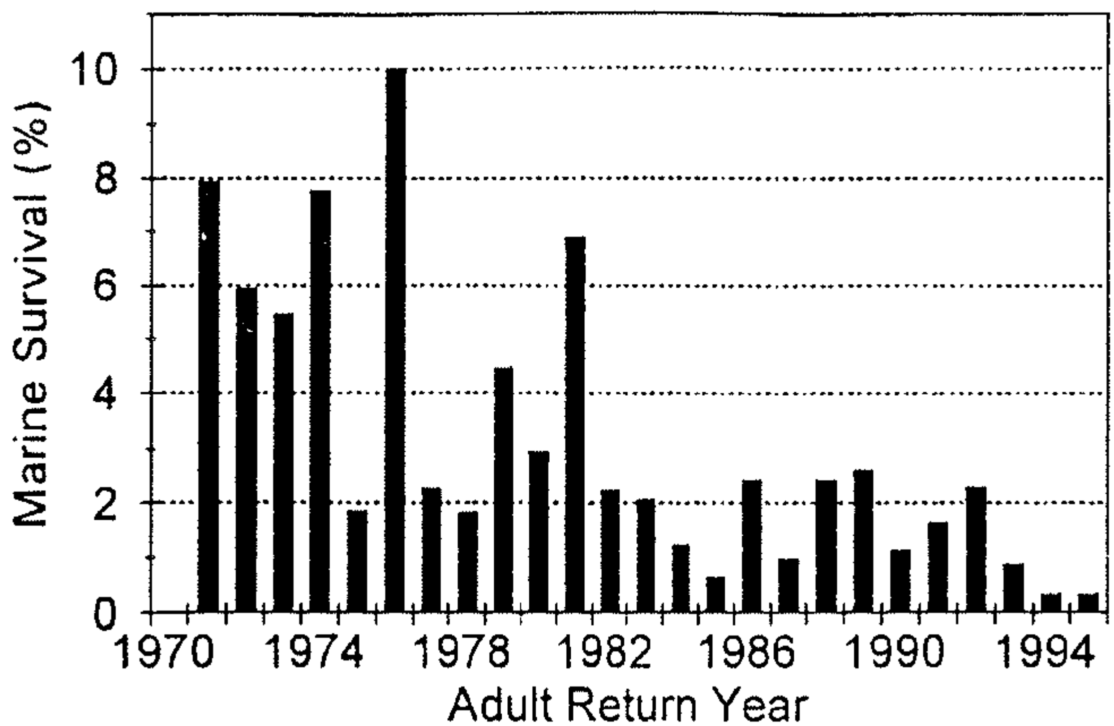

Figure 5-4. Marine survival of coho salmon smolts released from Fall Creek (Alsea River Oregon), 1970 to 1994. *Source: Emmett and Schiewe 1997.*

Marine survival for populations in Northern California, including the Klamath River, are typically below average when compared to other more northern states and provinces (Coronado and Hilborn 1998) and highly variable from year to year (Nickelson 2006). Once coho salmon have entered the marine environment, they tend to stay close to shore at first, feeding on plankton. As they grow larger, they move farther out into the ocean and switch to a diet of small fish, such as herring and squid (Groot et al. 1995). Pearcy (1992) speculated that protected bays, inlets, and shallow littoral areas that favor survival are rare off California and Oregon, which contributes to these populations' poor marine survival rates. In addition, oceanographic variability, resulting from inter-annual fluctuations in the intensity of upwelling or El Niño events, appears to be greater in the southern part of the species' range (Lestelle 2007).

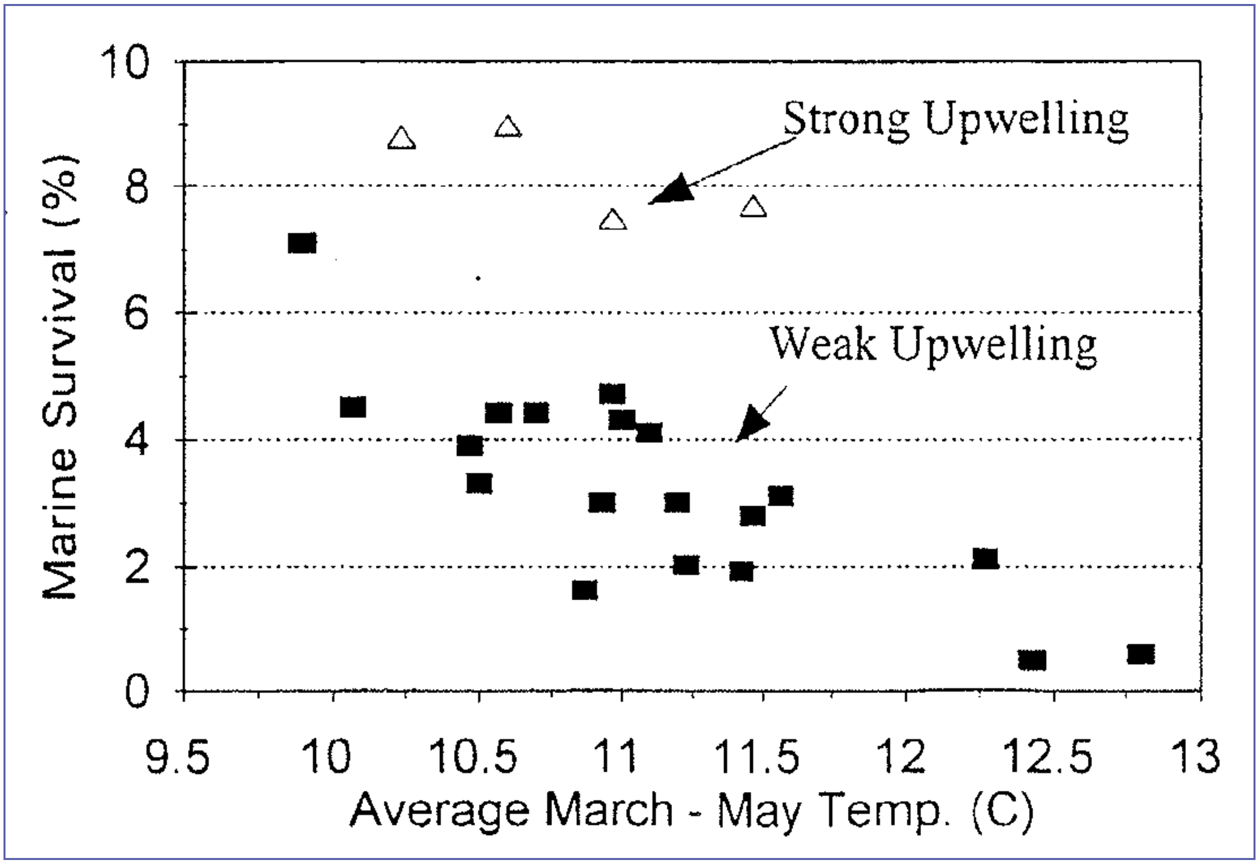

Figure 5-5. The influence of ocean temperature and coastal upwelling on marine survival of coho salmon released from Oregon hatcheries. *Source: Emmett and Schiewe 1997.*

5.2.2.1.2. Adult Freshwater Migration

Adult coho salmon typically begin entering the mouth of the Klamath River in September, with peak migration occurring in mid-October (Ackerman et al. 2006). The IGD is currently an upstream barrier to anadromous salmonid migrations in the mainstem Klamath River (Figure 5-6).

There is limited information available on residency of coho salmon in the estuary as adult coho salmon enter the Klamath River. However, in 2004, of five tagged coho salmon adult migrants, all but one proceeded through the estuary and initiated upriver migration in freshwater within 24 hours, with a mean estuary residence of 17 hours (Strange 2004). Although limited, this information does not suggest extensive estuarine delays.

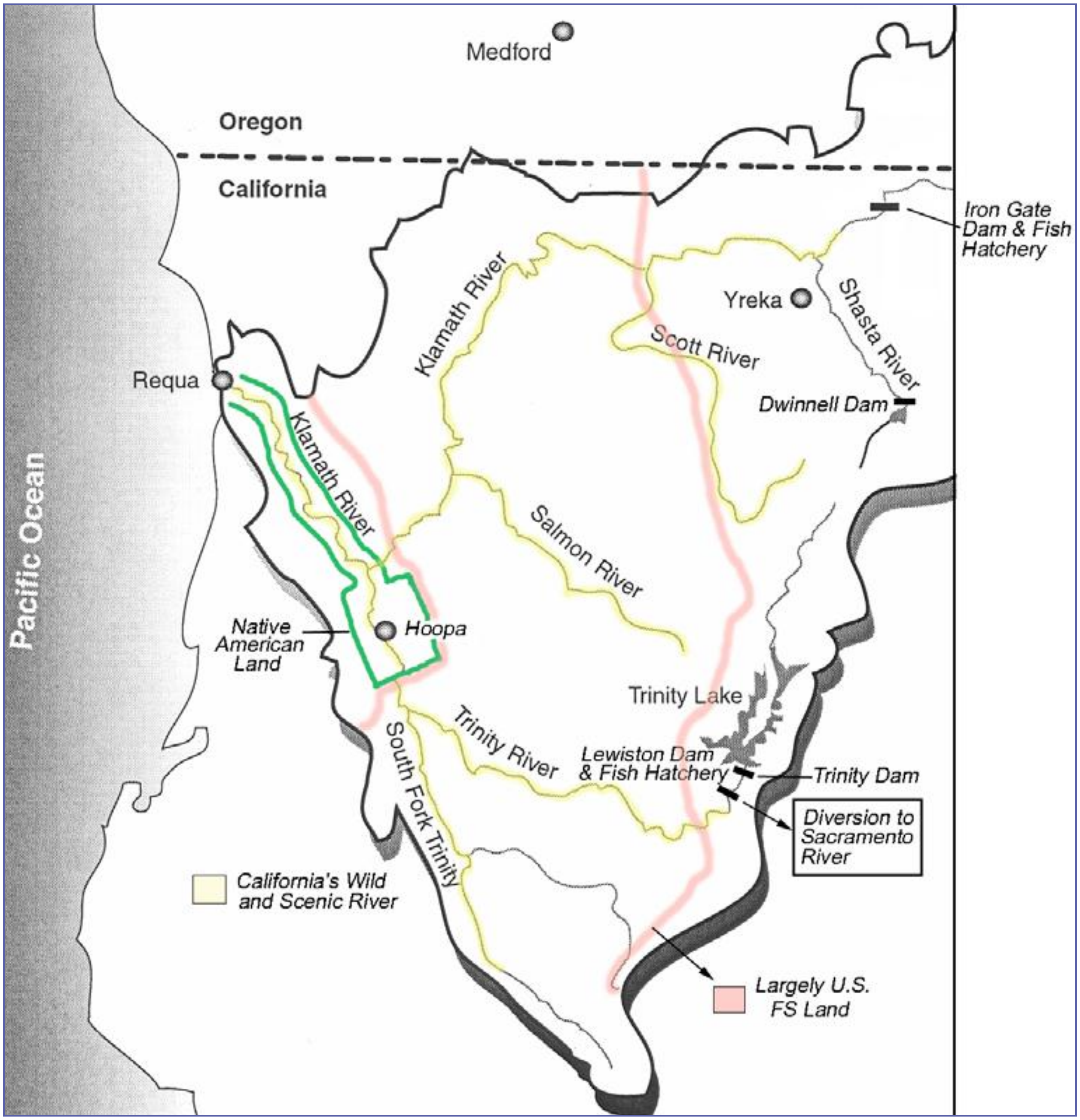

Figure 5-6. The Klamath River drainage downstream of the Iron Gate Dam. The Iron Gate Dam is currently an upstream barrier to anadromous salmonid migrations in the mainstem Klamath River.

Once within the Klamath River, adult coho salmon primarily use the mainstem as a migratory pathway to tributary spawning areas (Dunne et al. 2011). The vast majority of adults seek out spawning habitat in large tributaries such as the Scott, Shasta, and Trinity Rivers, as well as smaller mainstem tributaries.

It is possible that low mainstem flows during the fall may impede the passage of migrating adult coho salmon into the tributaries. However, mainstem flows are also not the only factor in potential blockage into the tributaries. Field studies conducted by Sutton (2007) indicate flows within tributaries are more important to passage than mainstem flows.

5.2.2.1.3. Spawning

Most coho salmon spawning occurs in the tributaries of the Klamath River from November through January. Thus, salmon migration into tributary natal streams often occurs during high flows typical during the fall (Koski 1966). In addition, the fall ambient air and water temperatures generally decrease and rainfall events occur at greater frequency (NMFS 2010), which assists the adult migration into the tributaries.

Limited mainstem spawning within the Klamath River has been recorded (Trihey and Associates 1996). For 2001 to 2004, Ackerman et al. (2006) estimated four percent or less of the total returning adult coho salmon to the Klamath River drainage salmon spawned in the mainstem of the Klamath River. From 2001 to 2005, Magneson and Gough (2006) documented a cumulative total of 38 coho salmon redds[9] in approximately 83 miles of the mainstem Klamath River, between IGD (river mile [RM] 190.5) and the Indian Creek confluence (RM 107.4). Coho salmon redds were observed in the mainstem Klamath River between November 15 and December 18, with the majority of new redds (63 percent) counted in mid-December. About 68 percent of observed redds were within approximately 12 RMs downstream of IGD. Many of these fish likely originated from Iron Gate Hatchery (NMFS 2010).

Magneson and Gough (2006) found all mainstem redds were constructed within approximately 1 RM of a tributary mouth.[10] This information suggests a strong influence of the tributary confluences to redd locations. In addition, Magneson and Gough (2006) observed coho salmon spawning in the mainstem Klamath River during IGD releases[11] ranging from a low of 882 cfs on December 3, 2002 to a high of 1,650 cfs on December 7, 2003.[12]

More recently, coho salmon redds were counted in 2008 (Slezak 2009). A total of nine coho salmon redds were observed during the survey. Eight of the nine redds (89 percent) were located in side channels or split channels of the mainstem Klamath River. The highest concentration of redds (n = 4) was found in a side channel near the confluence of Barkhouse Creek (RM 159.5). Slezak (2009) found the coho salmon redd counts from the survey comparable to the redd counts from 2002 to 2005, but are considerably lower than redd counts from 2001.

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[9] Average of 7.6 redds per year, with the highest observed of 13 redds in 2001. Redds are considered egg “nests” within streambed gravels.

[10] Willow Creek (RM = 188; n = 14), Cottonwood Creek (RM = 185; n = 5), Williams Creek (rRM = 182; n = 7), Barkhouse Creek (RM = 159; n = 8), Kohl Creek (RM = 154; n = 2), and Horse Creek (RM = 149; n = 2).

[11] As measured at USGS gauge 11516530.

[12] In 2001, the range was 1,300 cfs to 1,410 cfs (median 1,310); in 2002, the range was 882 cfs to 922 cfs (median 887 cfs); in 2003, the range was 1,350 cfs to 1,630 cfs (median 1,630 cfs), in 2004, the range was 925 cfs to 1,900 cfs (median 941 cfs); in 2005, the range was 1,330 cfs to 1,850 cfs (median 1,340 cfs).

5.2.2.2. Egg Incubation and Fry Emergence

Embryos develop and hatch in 8 to 12 weeks, depending on the water temperature. Alevins[13] remain in the gravel for another 4 to 10 weeks (Sandercock 1991). Fry emerge from the gravel as 1.2 to 2.0 inch (30 to 50 mm) fish and typically seek shallow stream margins for foraging and safety (NRC 2004). Within the Klamath River, fry begin emerging in mid-February and continue through mid-May (Leidy and Leidy 1984).

5.2.2.3. Fry

After emergence from spawning gravels, coho salmon fry distribute themselves upstream and downstream while seeking favorable rearing habitat (Sandercock 1991). Coho salmon fry have been found occupying habitats with water velocities of zero to 3.51 feet/s (1.07 meters per second [m/s]), with the most heavily utilized habitats having water velocities of 0.33 to 1.64 feet/s (0.1 to 0.5 m/s; Hardy et al. 2006). They use areas with water depths of 0.2 to 2.89 feet (0.06 to 0.88 m), with the most utilized habitats having water depths of 0.69 to 1.31 feet (0.21 to 0.40m; Hardy et al. 2006). Coho salmon fry are thought to grow best at water temperatures of 12 to 14ºC (Moyle 2002). Large woody debris and other in-stream cover are heavily utilized by coho salmon fry (Nielsen 1992, Hardy et al. 2006), indicating the importance of access to cover for coho salmon rearing.

Fry are non-territorial and most probably stay in the mainstem tributaries close to the areas in which they were spawned (NRC 2004). Downstream movement to the mainstem Klamath River of fry in the spring does occur, but its contribution to populations depends on the ability of these fry to find suitable habitats (Koski 2009). In the Klamath River Basin, the relocation of fry from tributaries to the mainstem may be a costly tactic for individual coho salmon. This is because the likelihood of survival under current conditions in the mainstem is low unless fish find suitable thermal refugia with the approach of summer (NRC 2004).

5.2.2.4. Juveniles

There is no sharp separation between fry and juvenile life stages. A central theme in the freshwater life history of juvenile coho salmon, as it was for the fry life stage, continues to be their close association with slow velocity habitats (Lestelle 2007). Unlike fry, however, juveniles typically partition available habitat among themselves through aggressive behavior (Sandercock 1991, Quinn 2005).

Lestelle (2010) has provided a conceptual model of seasonal habitat use and movement patterns by juvenile coho salmon in the Klamath Basin and breaks down the juvenile life stage into four components: spring re-distribution (and rearing), summer rearing, fall re-distribution (and rearing), and winter rearing. There is limited re-distribution occurring during the summer.

5.2.2.4.1. Spring Re-Distribution/Rearing

Juvenile salmonids relocate in order to avoid adverse environmental conditions or to optimize foraging opportunities, though it is likely that most juvenile coho salmon continue to remain

[13] Alevins are hatchlings with yolk sacs attached.

within their natal tributary to rear. The general trend during the spring re-distribution/rearing period is for small-scale movements within the tributaries to deeper water and for large-scale movements to be in an upstream direction toward cooler tributaries (Hay 2004). For example, within the Shasta River, Chesney et al. (2009) found that a rapid increase in the maximum daily water temperatures in the spring corresponded to juvenile coho salmon migrations of over four miles upstream to areas of cold spring inflow.

Based on the mainstem estimate of adult spawning provided by Ackerman et al. (2006), it is likely that four percent or less of the total natural-origin juveniles originate from the mainstem of the Klamath River in the years estimated. It is likely that some mainstem produced juveniles migrate into the tributaries during the spring. Likewise, some tributary juvenile coho salmon are also displaced into the mainstem Klamath River, such as from the Scott and Shasta Rivers, as irrigation diversions begin in early April (Chesney and Yokel 2003).

5.2.2.4.2. Summer Rearing/Re-Distribution

During the summer, the large majority of juvenile coho salmon continue to rear in tributaries (Stillwater 2010). These tributaries tend to have cooler stream temperatures in their upper reaches and warmer temperatures in their degraded lower reaches (NMFS 2012a).

However, observations of juvenile coho salmon suggest that limited juvenile coho salmon live in the mainstem during the summer despite temperatures that regularly exceed 24 degrees Celsius (°C; NRC 2004). One way that juvenile salmonids cope with high mainstem temperatures is by moving to pockets of cooler water, known as thermal refugia.

Refugia are highly variable in time and space and there are many factors that can impact the size, shape, and function of the refugia from a physical characterization perspective (Deas et al. 2006). For example, IGD flows can influence both the amount and extent of refugial habitat in the mainstem Klamath River. Deas et al. (2006) found that for a certain range of flows,[14] the refugia thermal conditions were largely unchanged. Deas et al. (2006) also found above certain flow thresholds (refuge dependent), refugial areas generally changed in lateral and longitudinal extent, and decreased in overall size. Deas et al. (2006) further concluded that the effects of meteorological conditions or tributary contributions played a larger role in refugial conditions than flow changes at IGD.

NRC (2004) found that coho salmon juveniles are uncommon in the mainstem in early summer and become progressively less common as the season progresses.[15] Juvenile coho salmon are virtually absent from the mainstem, including pools at tributary mouths, by late summer, even though juvenile Chinook salmon and steelhead persist in these habitats (NRC 2004). These fishes can compete with and prey on juvenile coho salmon (and each other) and are somewhat more tolerant of high temperatures than adult coho salmon (NRC 2004).

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[14] The highest flow observed during the study was 1,320 cfs in 2004.
[15] Snorkel surveys of mouth pools in 2001 show that juvenile coho salmon occupied 16 percent of the tributary-mouth pools in June, but only a single pool in August and September (*see* Table 7-3, NAS 2004).

NRC in their assessment failed to recognize the thermal diversity (network of cold water refugia including tributary streams) and year-to-year variability water temperatures during the early summer time period. Juvenile coho salmon are common in early summer when water temperatures are suitable (greater than 19°C). Moreover, Shasta River juveniles migrate into the mainstem Klamath in response to warming conditions in the lower Shasta River during late spring early summer. It was further noted the timing of "summer redistribution" into cool tributaries is variable, it can begin as early as May (during dry years) or as late as mid-July (wet year with cool conditions).[16]

Sutton et al. (2004) conjectured that summer cold fronts and thunderstorms can also lower mainstem temperatures, making it possible for juvenile salmonids to move out of mainstem thermal refugia during cooling periods in the summer. It is possible that coho salmon juveniles move to the lower Klamath River or the estuary, perhaps traveling in the early morning hours, when temperatures are lowest. However, the majority of the evidence indicates most juvenile coho salmon are not occupying the estuary through the summer (NRC 2004).

5.2.2.4.3. Fall Re-distribution/Rearing

As temperature declines in September, most juvenile coho salmon generally remain associated with local areas if environmental conditions are suitable, but may disperse if these conditions are not suitable. Food availability and competition are but two of many factors that may influence this response (NMFS 2010). In addition, as water velocities increase with rising flow typical during the fall, juveniles are either dislodging from summer rearing sites or stimulated to move to find more favorable habitats prior to the coming of larger, more frequent winter storms (Tschaplinski and Hartman 1983). This fall re-distribution movement is another demonstration of the affinity that these fish have for slow velocity water (Lestelle 2007).

As evidence of the fall re-distribution, the Yurok Tribal Fisheries Program and the Karuk Tribal Fisheries Program have been monitoring juvenile coho salmon movement in the Klamath River using (Passive Integrated Transponder) PIT tags since 2006. Following rainstorms during the months of November and December, several juveniles that were tagged at Independence Creek, at RM 95, were recaptured at the Big Bar trap at RM 51 (Soto 2008 as cited in NMFS 2010). Juveniles that migrate downstream in the Klamath River to off-channel ponds near the estuary are thought to remain and grow before emigrating as smolt the following spring (Voight 2008).

The number of juveniles in the tributary that re-distribute during the fall to the mainstem of the Klamath River is unknown. However, findings from out-of-Basin studies suggest that the percentage of tributary coho salmon that would likely re-distribute to the mainstem Klamath River in the fall would be low (Ackerman and Cramer 2007). Ackerman and Cramer (2007) reviewed four studies with information regarding the proportion of summer coho salmon populations that emigrate from tributary reaches in the fall. Utilizing these studies, Ackerman and Cramer (2007) estimated that between 3 to 11 percent of the summer mainstem rearing population will emigrate from tributaries into the mainstem of the Klamath River. These values

[16] Information provided by Toz Soto, Karuk Tribe in comments received on Draft Biological Assessment dated September 7, 2012.

represent the 20th and 80th percentiles of all emigration rates for each stream and all years reported in their review.

Sutton (2007) found that tributary passage for juvenile and adult salmonids is highly dependent on tributary flows and current channel configuration. Increasing mainstem Klamath River flows provided limited improvement to tributary access, depending on the hydraulic slope and flow in each tributary. Sutton (2007) concluded that while increased mainstem flows may provide improved access to tributary areas, tributary flows are the limiting factor for salmonids seeking tributary access.

5.2.2.4.4. Winter Rearing

Moyle (2002) suggests that the availability of overwintering habitat is one of the most important and least appreciated factors influencing the survival of juvenile coho salmon in streams. Even a stream that has suitable summer habitat for juvenile coho salmon may be unsuitable in winter. Juveniles need refuges from winter peak flows. Significant overwintering habitat includes ponds. Survival and growth rates in these ponds are typically higher than those that occur in runoff streams (Peterson 1982b; Lestelle 2007).

Since 2006, the Karuk and Yurok Tribes have conducted a multi-year study to assess key aspects of seasonal life history tactics of juvenile coho salmon within the mainstem Klamath River corridor. The tagging of juvenile coho salmon in the Klamath River with PIT tags during summer and fall, together with fyke net trapping at numerous sites within the mainstem corridor and stationary PIT tag detectors, show a significant re-distribution of coho salmon over the winter (Hillemeier et al. 2009). It appears the extent of this re-distribution during the winter is less for fish residing in the mainstem Klamath River upstream of Happy Camp (RM 110), where mainstem and tributary flow variation is generally small (Appendix 8A-7).

5.2.2.5. Smolt Outmigration

“Barred” juveniles transform into silvery smolt and begin migrating downstream in the Klamath Basin between February and mid-June (NRC 2004). Smolts are largely gone from the estuary by July (NRC 2004). The size of the fish, flow conditions, water temperature, DO, day length, and food availability contribute to migration timing (Shapovalov and Taft 1954). Migration rate tends to increase as fish move downstream (Stutzer et al. 2006).

In addition to the physiological aspects of smolting, several behavioral changes distinguish smolts from juveniles. Juveniles are territorial and live on or near the stream bottom, whereas smolts tend to develop schooling-type behavior[17] and swim at mid-depth (Kalleberg 1958). Buoyancy increases during smoltification, which may create difficulty maintaining a position on a stream bottom and thereby have some influence in initiating downstream movement. This behavioral response is probably at least one of the factors involved in the change from a predominantly bottom living existence in freshwater to a pelagic one in salt water (Saunders 1965). With increased buoyancy, Flagg and Smith (1981) found that during smoltification, coho

[17] Smolt do not rigidly form schools but exhibit a degree of plasticity in behavior dependent upon environmental conditions (Paszkowski and Olla 1985).

salmon also undergo a hormonally induced decrease in swimming proficiency which may be an important component in downstream migration.

McMahon and Holtby (1992) found that aggregating (e.g., schooling type behavior) and cover-seeking behavior of smolts represents a continuation of, rather than a marked shift from, behavior of coho salmon juveniles during winter. In winter, aggression declines and coho salmon form aggregations near cover (Bustard and Narver 1975, Tschaplinski and Hartman 1983, McMahon and Hartman 1989).

As with juveniles in winter, association with cover features likely provides smolts with shelter from high current velocities and protection from predation. Shelter from high velocity is likely important to prevent premature displacement prior to completion of smoltification (Hartman et al. 1982), especially since smolts exhibit reduced swimming abilities (Flagg and Smith 1981**.** The importance of and multiple functions of woody debris in streams for rearing coho salmon have also been well documented (e.g., Bisson et al. 1987).

In regards to smolt survival rates, in a four-year study, Beeman et al (2012) determined apparent survival and migration rates of yearling coho salmon in the Klamath River downstream of IGD. The data collected supported positive effects of water temperature (increased temperate, increased survival), river discharge (increase discharge, increased survival), and fish weight as factors affecting apparent survival in the Klamath River upstream of the confluence with the Shasta River.

Beeman et al. (2012) found that the increase in survival in the release to Shasta River reach with each 1°C increase in water temperature was 1.4 times the effect of a 100 cfs increase in river discharge and 2.5 times the effect of one gram increase in fish weight, and the effects of discharge and weight diminished at higher water temperatures up to the 17.91°C maximum present in the data examined. The effect of water temperature on apparent survival upstream of the Shasta River was greater than IGD discharge, which was greater than fish weight.

Beeman et al. (2012) also found few of the variables examined were supported as factors affecting survival farther downstream of the confluence with the Shasta River. They also found that the survival of juvenile coho salmon migrating seaward in the Klamath River downstream of IGD was similar or greater than survival of juvenile salmonids in several other regulated river systems.

The results of this study indicate that increasing discharge at IGD can increase survival upstream of the Shasta River, but the effect would be small relative to seasonal increases in water temperature. Beeman et al. (2012) further concluded that the greatest survival benefit of higher IGD discharge would be when water temperatures are low, which in this study generally were prior to May, although the low passage rates during this time suggest that the benefit to survival is not from faster downstream migration, but through other mechanisms.

5.2.2.6. Mainstem Klamath River Usage

The use of the mainstem Klamath River is of particular interest in this consultation. Implementation of the Proposed Action would primarily impact IGD releases. Thus, the mainstem of the Klamath River is primarily impacted by the implementation of the Proposed Action. The Yurok and Karuk Tribes have extensively studied the seasonal distribution and habitat use patterns of pre-smolt juvenile coho salmon within the mainstem of the Klamath River (Soto et. al, 2008; Hillemeier et al. 2009).

Hillemeier et al. (2009) suggested movement patterns of juvenile coho salmon within the mainstem Klamath River include:

1. Fry that disperse from natal tributaries enter the mainstem corridor during spring runoff.

2. Some juveniles within corridor habitats move again in early summer with rising water temperatures in search of thermal refuge. Little movement is believed to occur for the remainder of summer.

3. Re-distribution is also expected to occur in fall and early winter during periods of increased flows as juveniles search for suitable overwintering habitats. Rate of movement slows significantly following the bulk of redistribution with stable residency following.

4. Smolt migration begins in early spring.

The Yurok and Karuk Tribes used PIT tagging technology to assess movements of individually identified fish in conjunction with the extensive trapping and seining activities (Hillemeier et al. 2009). Between May 2007 and May 2008, more than 2,700 juvenile coho salmon were successfully PIT-tagged and released. The longest distance traveled by a tagged fish that re-entered one of the tributaries in the Lower Klamath study area, and was recaptured, was 125 miles. That fish was tagged on September 18, 2007 in Fort Goff Creek, and then was recaptured in Salt Creek on May 10, 2008. It is not known for certain, however, where this fish overwintered, though Hillemeier et al. (2009) speculated it was in Salt Creek. The longest redistribution of a fish known to overwinter in the Lower Klamath study area was 114 miles. That fish was tagged on August 14, 2007 in China Creek, then was recaptured moving upstream in Junior Pond Creek on January 2, 2008 (Hillemeier et al. 2009).

Two streams routinely monitored for fish abundance during spring, summer, and fall were the Independence floodplain channel (RM 94) and Cade Creek (RM 112). A brief discussion on Hillemeier et al. (2009) results provides some understanding on how juvenile coho salmon utilized these two systems.

Hillemeier et al. (2009) referred to this Independence floodplain channel as a tributary-fed floodplain channel, which occurs on the inside edge of meander bends where a small tributary enters (Figure 5-7). Because Independence Creek can discharge relatively high flows, and the entire length of the floodplain channel is affected by this stream. Some natal production of coho salmon has been observed in Independence Creek, but non-natal use was documented to occur here in summer of 2007, when a large number of YOY moved into the site. Figure 5-8 depicts the abundance estimate of juvenile coho salmon utilizing the Independence floodplain channel (Hillemeier et al. (2009).

Cade Creek (RM 112) is a small tributary entering the Klamath River in the middle section of the study area that supports non-natal coho salmon production (Figure 5-9). Spawning and juvenile rearing surveys indicate that the stream is only rarely, if at all, used for spawning. Hillemeier et al. (2009) found that water temperature in the mainstem Klamath River was hitting 19ºC at the time when coho salmon began arriving to Cade Creek. The number of juvenile coho salmon moving into the stream increased as temperatures continued to rise. Hillemeier et al. (2009) speculated that the decline in catches made in the minnow traps is likely due to the fish moving further upstream, away from the site where the traps were deployed (Figure 5-10).

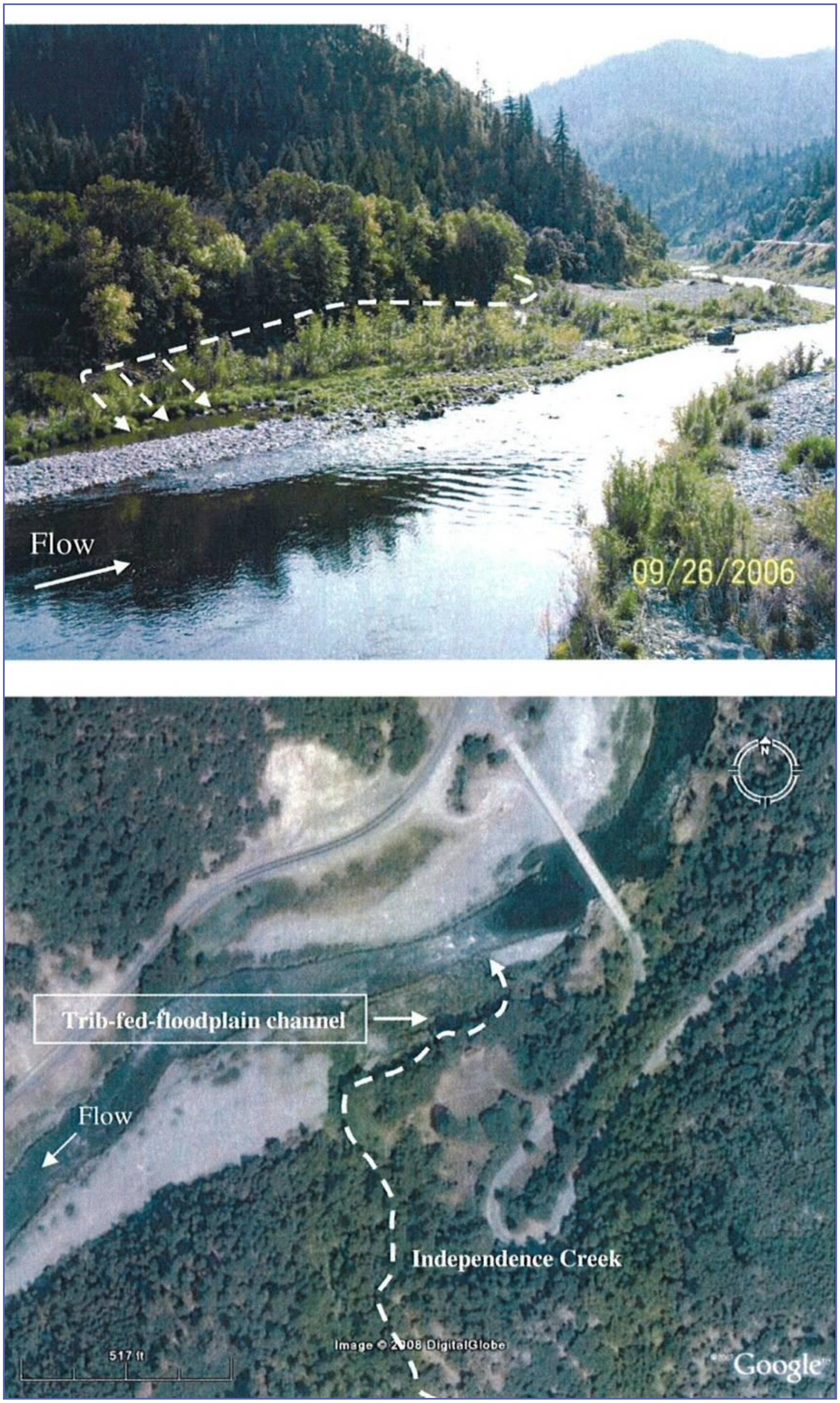

Figure 5-7. Independent Creek floodplain channel.
Source: Hillemeier et al. 2009.

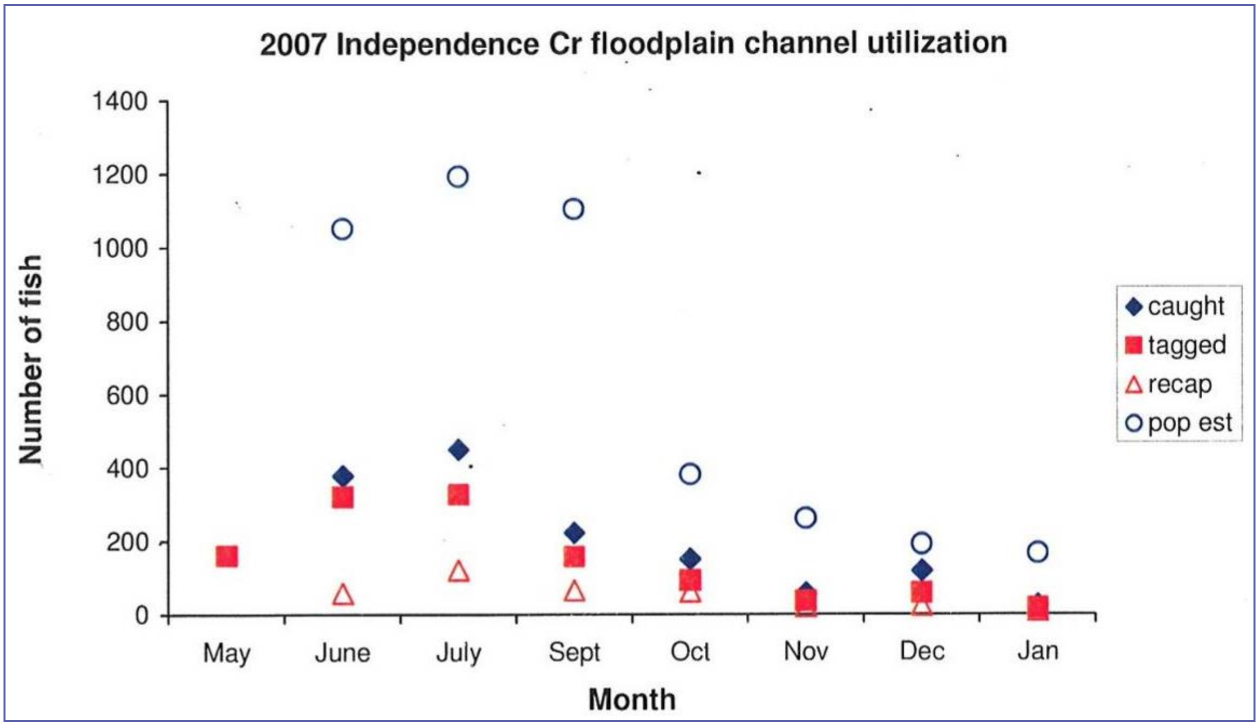

Figure 5-8. Preliminary results of applying an approach of grouping data to estimate abundance (population estimate) of juvenile coho salmon in the Independence Creek floodplain channel using a simplified Peterson estimator. *Source: Hillemeier et al. 2009.*

Figure 5-9. Lower Cade Creek. *Source: Hillemeier et al. 2009.*

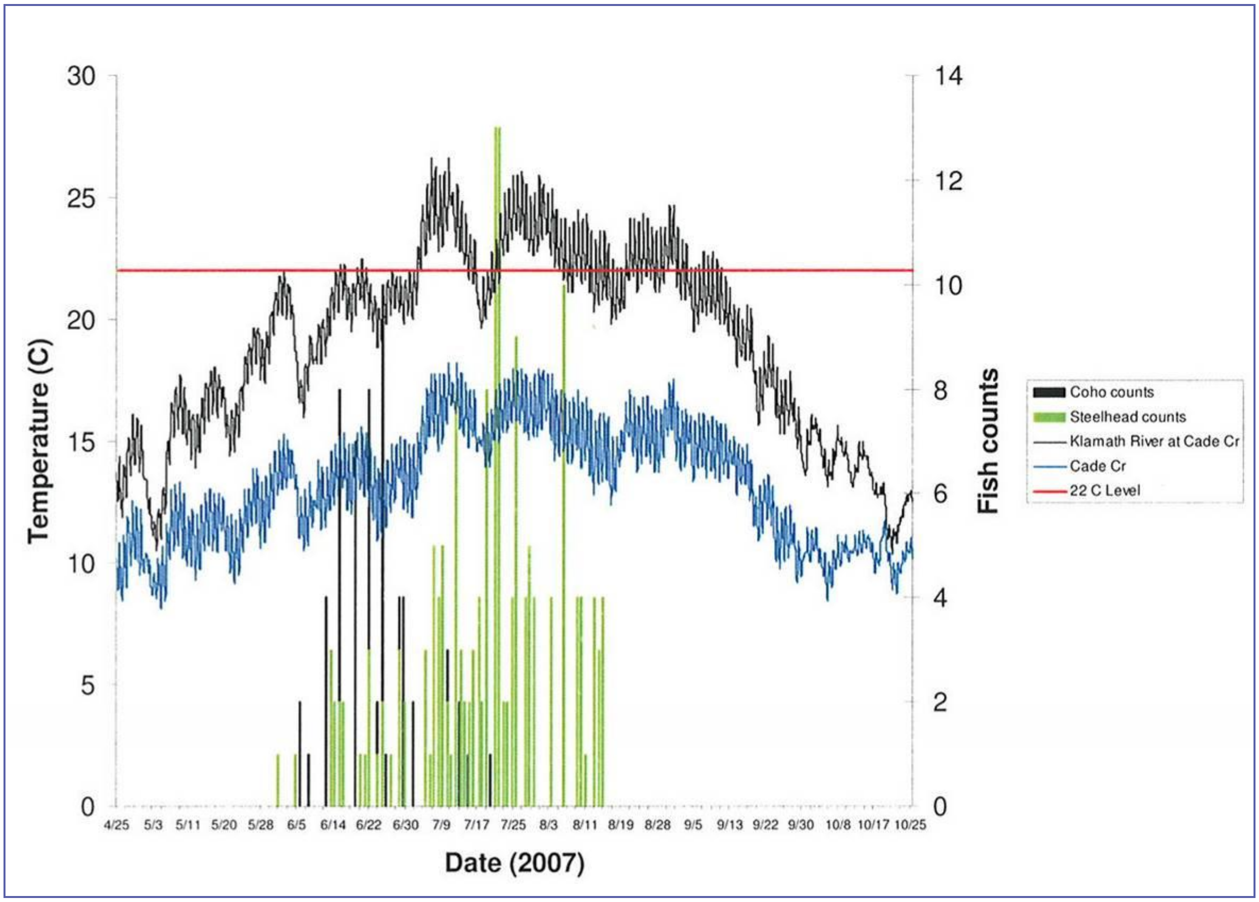

Figure 5-10. Timing of juvenile coho salmon and steelhead movements into Cade Creek relative to mainstem Klamath and tributary temperatures during summer 2007. Black and green vertical bars are coho salmon and steelhead catches, respectively. Fish numbers represent catches made by minnow traps in the lower reach of the stream Graph is from Sutton (2009). The red horizontal line corresponds to 22°C. *Source: Hillemeier et al. 2009.*

5.2.3. Status and Trend

NMFS evaluates the population viability by utilizing four parameters: abundance, productivity (growth rate), spatial structure, and diversity (McElhany et al. 2000). Reclamation will use this same structure in evaluating the status of the SONCC coho salmon ESU and select populations within the ESU.

Population Size: Long-term data on coho salmon abundance are scarce, but the available monitoring data indicate that spawner abundance has declined for populations in this ESU. The longest existing time series at the population unit scale is from the past 10 years for Shasta River, which has a significant negative trend (Knechtle and Chesney 2011). Two partial counts from Prairie Creek, a tributary of Redwood Creek, and Freshwater Creek, a tributary of Humboldt Bay also show a negative trend (Williams et al. 2011, Ricker and Anderson 2011). In the Rogue River Basin, the 12-year-average estimated wild adult coho salmon between 1998 and 2009 is 7,414 (ODFW 2005b), which is well below historic abundance of 114,000 coho salmon in the late 1800s (Meengs and Lackey 2005).

Though population-level estimates of abundance for most independent populations are lacking, the best available data indicate that none of the seven diversity strata appears to support a single viable population. To the contrary, most of the 30 independent populations in the ESU are at high risk of extinction because they are below or likely below their depensation threshold.[18]

Sharr et al. (2000) modeled the probability of extinction of most Oregon Coast Natural populations and found that as spawner density dropped below four fish/mile (2.4 spawners/km) the risk of extinction rose rapidly. In addition, populations that are under depensation have increased likelihood of being extirpated.

Extirpations have already occurred in the Eel River Basin and are likely in the interior Klamath River Basin for one or all year classes (e.g., Shasta and Scott Rivers), Bear River, and Mattole River. Because the extinction risk of an ESU depends upon the extinction risk of its constituent independent populations (Williams et al. 2008) and the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable.

Population Productivity: Available data indicates that many populations have declined, which reflects a declining productivity. In general, SONCC coho salmon have declined substantially from historic levels. Because productivity appears to be negative for most, if not all SONCC ESU coho salmon populations, this ESU is not currently viable in regard to population productivity.

Spatial Structure: Data is inadequate to determine whether the spatial distribution of SONCC ESU coho salmon has changed since 2005. There is considerable year-to-year variation in estimated occupancy rates, but it appears there has been no dramatic change in the percent of coho salmon streams occupied from the late 1980s and early 1990s to 2000 (Good et al. 2005). However, the number of streams and rivers currently supporting coho salmon in this ESU has been greatly reduced from historical levels, and watershed-specific extirpations of coho salmon have been documented (Brown et al.1994, Good et al. 2005, Moyle et al. 2008). In summary, recent information for the SONCC ESU of coho salmon indicates that their distribution within the ESU has been reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which they are now absent (NMFS 2001). However, extant populations can still be found in all major river basins within the ESU (70 FR 37160; June 28, 2005).

Diversity: The primary factors affecting the diversity of SONCC ESU coho salmon appear to be low population abundance and the influence of hatcheries and out-of-Basin introductions. Although the operation of a hatchery tends to increase the abundance of returning adults (70 FR 37160; June 28, 2005), the reproductive success of hatchery-born salmonids spawning in the wild can be less than that of naturally produced fish (Araki et al. 2007). Because the main stocks in the SONCC coho salmon ESU (i.e., Rogue, Klamath, and Trinity Rivers) remain heavily

[18] Depensation is the effect on a population whereby a decrease in the breeding population leads to reduced survival and production of eggs or offspring.

influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp et al. 1995, Good et al. 2005), many of these populations are at high risk of extinction relative to the genetic diversity parameter.

5.2.4. SONCC Coho Salmon ESU Populations

A population is defined as a group of fish of the same species that spawn in a particular location at a particular season and does not interbreed substantially with fish from any other group (McElhany et al. 2000). Since there is a strong tendency for coho salmon to return to their natal stream to spawn (Quinn 1993), the resulting population structure is largely determined by the spatial arrangement of their natal streams, including the structure of freshwater spawning and rearing habitats and migration pathways that allow dispersal among these habitats. Figure 5-11 depicts the population structure of the SONCC coho salmon ESU.

The four coho salmon populations in the upper portions of the drainage will experience the greatest magnitude and intensity of stressors, relative to the Proposed Action, on their viability based on their proximity to IGD. These four populations are the: Upper Klamath, Shasta, Scott, and the Middle Klamath River Populations.

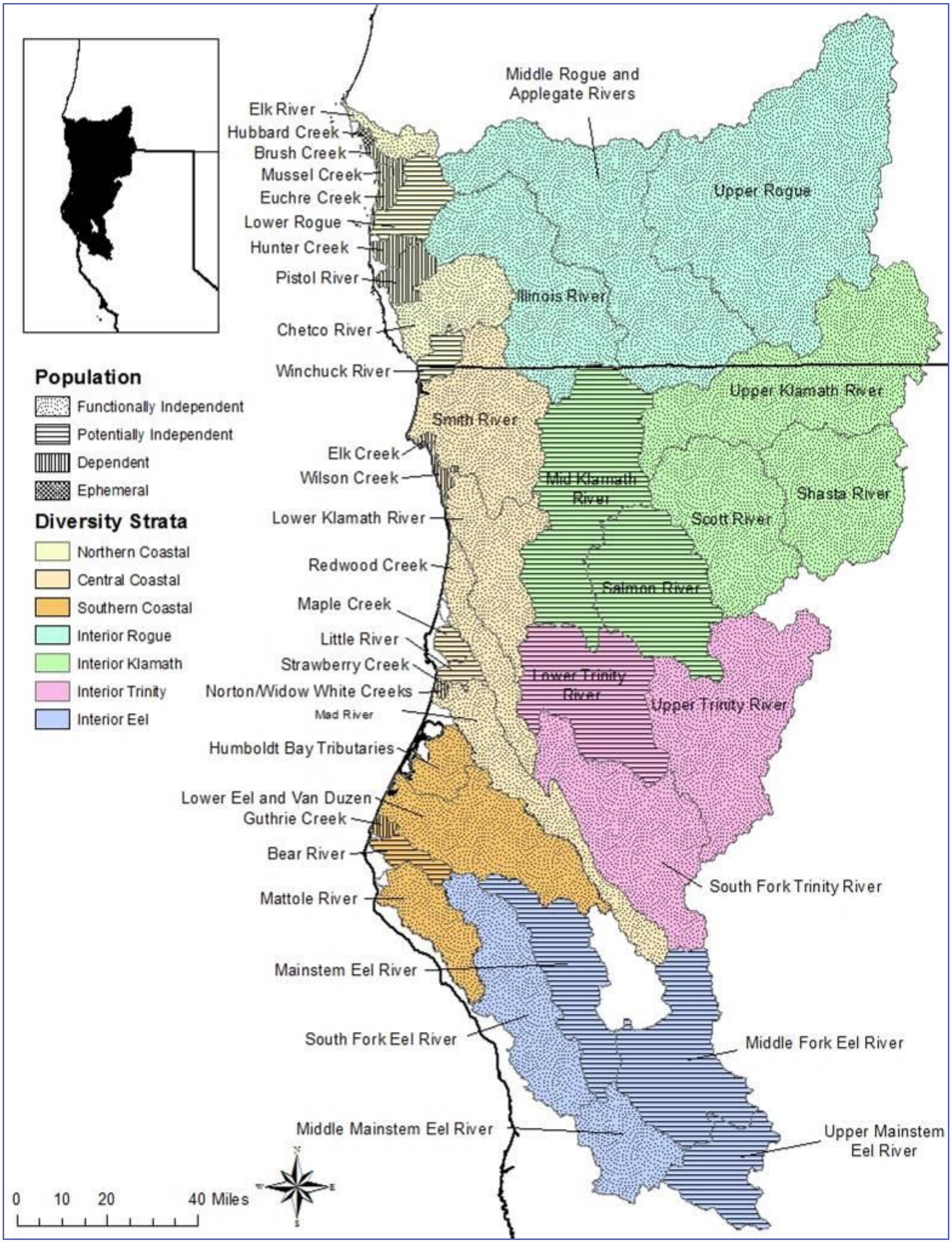

Figure 5-11. Historic population structure of the Southern Oregon/Northern California Coast coho salmon ESU (modified from Williams et al. 2006 in NMFS 2012b).

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Part 6 ENVIRONMENTAL BASELINE

The Environmental Baseline includes "the past and present impacts of all federal, state, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 C.F.R. 402.02). The Environmental Baseline provides a reference condition to which the effects of operating the Project (Project) are added, as required by regulation ("effects of the action" definition in 50 C.F.R. 402.02).

The following discussion on the Environmental Baseline contains a level of detail beyond what is generally required for a BA. However, select elements of the Environmental Baseline are discussed in this BA to provide a basis for the Effects Analysis contained in Parts 7 and 8 of this document. A more thorough discussion can be found in prior ESA consultation documents (e.g., *NMFS 2010 Biological Opinion on Operation of the Klamath Project Between 2010 and 2018* and the *USFWS 2008 Biological/Conference Opinion Regarding the Effects of the U.S. Bureau of Reclamation's Proposed 10-Year Operation Plan (April 1, 2008 to March 31, 2018) for the Klamath Project and its Effects on the Endangered Lost River and Shortnose Suckers*).

6.1. Climate Change

Climate change has some general long-term implications for the Klamath Basin, including warming of air and water temperatures, changes in precipitation (i.e., amount of rain versus snow, and frequency of rain on snow events), the amount of snowpack, water quantity (e.g., more frequent, high intensity storms, and lower summer flows), and overall seasonal streamflow patterns (National Research Council [NRC] 2004). General climate trends identified in the Western U.S. suggest that historical 20th century warming is projected to continue with estimates varying from roughly 5 to 7 degrees Fahrenheit (°F) during the 21st century, depending on location (Reclamation 2011). It should be noted that it is not entirely clear whether observed changes are due to natural climate *variability* or climate *change* (Reclamation 2011).

Over the course of the 20th century, Klamath Basin average mean-annual temperature has increased by approximately 2°F in Jackson and Klamath Counties in south-central Oregon and Siskiyou County in north-central California (though large variations in annual temperature has been observed and the warming has not been steady; Reclamation 2011). The warming rate of air temperatures for the Pacific Northwest over the next century is projected to be approximately 0.1 to 0.6°C per decade (ISAB 2007). Model results suggest that water temperatures in the Klamath River above Klamath, California, are projected to increase by approximately 5 to 6°F during the 21st century. Temperatures averaged over just the upper portion of the Basin (Klamath River above IGD) are projected to have a similar trend (Reclamation 2011). Flint and Flint (2012) found indications that warming conditions have already occurred in many areas of the Klamath River Basin, and that the stream temperature projections for the 21st century could be underestimating the actual change.

Projections suggest that some Western river basins may gradually become wetter (e.g., Columbia Basin) while others gradually become drier (e.g., San Joaquin and Truckee). The Klamath and Sacramento Basins have roughly equal chances of becoming wetter or drier (Reclamation 2011); Klamath Basin annual precipitation has fluctuated considerably during the past century, varying between 20 to 45 inches (Reclamation 2011).

Projection of climate change is geographically complex and varies considerably within the Klamath River Basin, particularly for precipitation. Precipitation conditions are generally wetter towards the coast and on the windward side of coastal mountain ranges, and precipitation tends to decrease towards the east and relatively arid conditions exist over the northern reaches of the Basin. Mean annual temperature in the lower Basin is warmer than the upper Basin, and the lower Basin experiences less variation in seasonal temperatures. Annual average temperatures are generally cooler in the interior plateau areas of the upper Basin, while warmer temperatures are observed in lower lying areas of the lower Basin and near the California coast (Reclamation 2011). The overall precipitation change projection suggests a slight increase over the entire Basin during the early 21st century, transitioning to a northern increase and southern decrease by the 2070s (Reclamation 2011).

Increased warming is expected to diminish the accumulation of snow during the cool season (i.e., late autumn through early spring), the availability of snowmelt to sustain runoff during the warm season (i.e., late spring through early autumn), and reduce snow-water equivalents (NMFS 2010, Reclamation 2011). Generally, snowpack decrease is projected to be more substantial over the portions of the Basin where Baseline cool season temperatures are generally closer to freezing thresholds (e.g., lower lying valley areas and lower altitude mountain ranges) and more sensitive to projected warming. In high altitude and high latitude areas, there is a chance that cool season snowpack actually could increase during the 21st century, because precipitation increases are projected and appear to offset the snow-reduction effects of warming in these locations (Reclamation 2011). This conceptually leads to increases in December-March runoff and decreases in April-July runoff, though the degree to which these results bear out in the Klamath River Basin appears to vary by subbasin (Reclamation 2011).

For example, the Wood River and the Shasta River both have headwater and groundwater recharge areas that lie at sufficiently high elevation to be more resilient than most stream reaches in the event of temperature increases and associated changes in precipitation (NRC 2004). In a study of the Klamath Basin, Mayer and Naman (2011) suggest that streamflow characteristics and response to climate vary with stream type between surface (rain basins and snowmelt basins) versus groundwater dominated basins. They posit that in the groundwater basins that sustain UKL inflows and mainstem river flows during the typically dry summers, the streamflow response to changes in snowpack is smoothed and delayed and the effects are extended longer in the summer. Changes in snowpack, annual runoff, and runoff seasonality within the Klamath River Basin could change the availability of natural water supplies, (NMFS 2010, Reclamation 2011), increase the demand for water by humans (Döll 2002, Hayhoe et al. 2004), and decrease water availability for salmonids (Battin et al. 2007).

At present, most projected ecosystem impacts of climate changes to fisheries are associated with increases in air and water temperatures and include increased stress on fisheries that are sensitive to a warming aquatic habitat (Reclamation 2011). For example, water temperature

1. Influences the time required for fish eggs to develop and the rate at which fry and juvenile fish grow;

2. Are likely to lead to shorter incubation periods and faster growth and maturation of young fish (Beckman et al., 1998);

3. Can increase metabolic costs and decrease growth during summer (Healy, 2006);

4. Causes earlier entry of juvenile salmon into the ocean; and

5. Increases exposure of fish to diseases and potentially alter the resistance of aquatic organisms to pathogens and parasites (Marcogliese, 2001; OCCRI, 2010).

Distributions of different types of cold-water refuge habitats in alcoves (side channels) on floodplains and in-channel gravel bars (Hulse and Gregory, 2007; Burkeholder et al., 2008), and created by the exchange of stream waters and ground waters, could determine the future distributions and abundances of native cold-water fishes under warmer climate regimes (OCCRI, 2010). However, few studies have directly linked the use of cold-water habitats with the processes that create and maintain these essential refuges (OCCRI, 2010).

The ability to use storage resources to control future hydrologic variability and changes in runoff seasonality is an important consideration in assessing potential water management impacts due to climate-induced runoff changes. Increased winter runoff under climate change will not necessarily translate into increased storage of water leading into the spring season, as a result of limited storage capacity. When the future climate scenario is adjusted to reflect projected warming with precipitation increase (e.g., over the upper reaches tributaries to UKL), the conceptual effects on reservoir operations are less obvious, since changes in precipitation can offset some of the warming effects on spring–summer runoff.

While most predicted effects of climate change cannot be forecast to occur within the 10-year time frame of this consultation, some may occur as early as the 2020s, such as increased mean seasonal runoff volume for December through March[19] (Reclamation 2011, Table 3), and some studies suggest that the streamflows of the upper Klamath Basin may already be experiencing the effects of climate change (e.g., Mayer and Naman, 2011). It is important to acknowledge that the effects of climate change may be a factor in the operation of the Klamath Project in the future. However, the magnitude of the future effects, if any, is currently unknown and is likely to occur on a timescale that is outside of the scope of this consultation.

[19] Simulated changes in decade-mean hydroclimate suggest increases in flows of 22.3 percent in the Williamson River below Sprague River; 16.9 percent in the Klamath River near Seiad Valley; and 8.7 percent in the Klamath River near Klamath (Reclamation 2011).

6.2. Lost River and Shortnose Suckers

6.2.1. Factors Affecting Suckers and their Habitat

6.2.1.1. Loss of Historical Populations and Range

The historical range of Lost River and shortnose suckers has been severely reduced by drainage and management of Lower Klamath and Tule Lakes. Historically, both sucker species occurred throughout the Upper Klamath Basin. Both sucker species are present in UKL and tributaries, Clear Lake Reservoir and tributaries, Klamath River impoundments to IGD, the Lost River, and the Tule Lake sumps (USFWS 2002). A shortnose sucker population is present in Gerber Reservoir (USFWS 2002).

The loss of historic populations and range is a continued threat to both the Lost River and shortnose suckers. Although the cause for each lost population is not entirely understood, several populations of suckers are now extirpated (USFWS 2002). Populations of suckers were historically noted in Lake of the Woods and Lower Klamath Lake (including Sheepy Lake). Sucker populations were also noted in several small reservoirs on Willow Creek in the Clear Lake subbasin until consecutive drought years in the 1990s (USFWS 2002). Repopulation of these small reservoirs is probable, but not known (USFWS 2002). Suckers once spawned at Barkley Spring on the eastern shoreline of UKL and at several areas along the northwestern shoreline of UKL near Pelican Bay. Sucker spawning activity has not been observed since the early 1990s and is presumed to no longer occur at several of these locations (NRC 2004).

The range of Lost River and shortnose suckers has not expanded nor contracted substantially since listing in 1988. Since 1988, additional sucker populations have been identified in isolated sections of the Lost River drainage, within the historical range for both species that includes a population of shortnose suckers in Gerber Reservoir and small populations of each species in Tule Lake (USFWS 2002). Given the lack of connectivity between populations created by past and present water management and land use practices, suckers are not likely to repopulate disconnected bodies of water where they once resided.

6.2.1.2. Habitat Loss, Degradation, and Fragmentation

The diking and draining of wetlands throughout the Klamath Basin have been well documented in previous section 7 consultations (Reclamation 2001a, USFWS 2002). In the late 1800s, prior to most watershed development, approximately 223,000 to 330,000 acres (average = 276,000 acres) of shallow lake and associated wetland habitat existed. Presently, 76,000 to 122,000 acres (average = 99,000) of shallow lake and wetland habitat exist in the Basin (Reclamation 2001a). Overall, aquatic habitat available to suckers has decreased approximately 64 percent (or 177,000 acres) over the last century. No assessment of the amount of habitat needed to sustain a viable population is available. A concurrent, substantial decline in sucker populations over this time period was related in part to the large loss of lake and wetland habitat areas and blocked access to spawning and rearing areas and entrainment losses resulting from diversions (Reclamation 2002).

Review of recent U.S. Army Corps of Engineers section 7 ESA consultations indicates that some relatively minor wetland losses still occur in the Upper Klamath Basin, but effects of these actions on sucker populations are minimized during project planning and consultation (USFWS 2007a, 2007b). Dams block sucker migration corridors, isolate population segments, and concentrate suckers in limited spawning areas, possibly increasing the likelihood of hybridization between species (Reclamation 2001a). Dams may also result in stream channel changes, alter water quality, and provide habitat for exotic fish that prey on suckers or compete with them for food and habitat (Reclamation 2001a). There are seven major Project dams that fragment the habitats of listed suckers, including Clear Lake, Link River, Gerber, Malone, Miller Creek, Lost River Diversion (Wilson), and Anderson-Rose Dams. Only the Link River Dam is equipped with a fish ladder designed specifically to allow sucker passage, which was installed and operational at the Link River Dam in spring 2005.

6.2.1.2.1. Habitat in Upper Klamath Lake Recovery Unit

A significant hydrological characteristic of UKL is its surface elevation, which fluctuates annually about 3 feet (0.9m) in near-normal years and about 5 to 6 feet (1.5 to 1.8m) in dry years. UKL is a natural water body, but lake surface elevations have been regulated since 1921 when Link River Dam was completed (Table 6-1). Water is released for irrigation, wildlife refuge maintenance, hydropower generation, flood control, and instream flows to support downstream fish habitat (Buchanan et al. 2011). UKL elevations rise from fall through spring associated with increased inflows and reduced diversions. The higher range of surface lake elevations occur in the spring and control the area of seasonally inundated lakeshore wetlands, which have been reduced in the past century by diking and drainage (Buchanan et al. 2011). These wetlands are considered to be favorable rearing habitat for early life history stages of resident fishes and to be a sink for phosphorous and a source for tannic acids which counter the growth of blue-green algae in lake waters (NRC 2004, Aquatic Scientific Resources [ASR] 2005). During late-spring and summer, lake levels decline in response to decreasing tributary inflow, support of downstream flows, and agricultural withdrawals (Buchanan et al. 2011).

Table 6-1. The percent of area with at least one-foot water depth at spawning sites along the eastern shoreline of Upper Klamath Lake is related to lake surface elevation and differs slightly between spawning locations.

Lake Elevation (North American Vertical Datum 88)	Lake Elevation (Reclamation Datum)	Sucker Springs	Silver Building Spring	Ouxy Spring	Cinder Flat	Composite of Shoreline Spawning
4,144.53	4,142.5	92				90.5
4,144.03	4,142.0	77	70	61	87	73.8
4,143.53	4,141.5	63				62.0
4,143.03	4,141.0	53	48	25	73	49.8
4,142.53	4,140.5			0+		36.7
4,142.03	4,140.0	33				30.2
4,141.53	4,139.5					17.6

Table 6-1. The percent of area with at least one-foot water depth at spawning sites along the eastern shoreline of Upper Klamath Lake is related to lake surface elevation and differs slightly between spawning locations.

Lake Elevation (North American Vertical Datum 88)	Lake Elevation (Reclamation Datum)	Sucker Springs	Silver Building Spring	Ouxy Spring	Cinder Flat	Composite of Shoreline Spawning
4,141.03	4,139.0		0+			13.8
4,140.53	4,138.5	0+				7.3
4,140.03	4,138.0				0+	5.2

Source: Reclamation 2001a, 2002.

Spawning currently occurs in the Williamson and Sprague Rivers and at a few shoreline spawning areas along the eastern shore of UKL. Spawning at shoreline areas is predominately by Lost River suckers (Hayes et al. 2002). Suckers have access to approximately 85 miles of riverine habitat for spawning and rearing in the Williamson and Sprague Rivers (Ellsworth et al. 2007). A small number of shortnose suckers may also spawn in the lower Wood River (USFWS 2008a).

Lake level management does not impact access to (or spawning) in the Williamson, Sprague, and Wood Rivers. Of the eastern shoreline spawning areas, spawning has been observed in recent years at Sucker Springs, Silver Building Springs, Ouxy Springs, Cinder Flat, and Boulder Springs (Figure 6-1; Perkins et al. 2000a, Hayes et al. 2002, Janney et al. 2007). Whereas, shoreline spawning has previously been thought to occur from late February to early June with peaks in early April through mid-May (Janney et al. 2007, Buchanan et al. 2011), few marked adult Lost River suckers are detected arriving in late February at the shoreline spawning areas (Janney 2012, pers. comm.). A recent review of data suggests spawning at shoreline springs is temperature-dependent with spawning activity starting when UKL temperatures are 5 to 6°C (typically during the first two weeks of March). Peak spawning at the shoreline areas is temperature-dependent and typically occurs during the first three weeks of April (Janney 2012, pers. comm.). Filling the lake early during spring months (i.e., February, March, and April) ensures access to suitable shoreline spawning areas in addition to increasing the probability of achieving adequate lake levels through the summer (Buchanan et al. 2011).

Nighttime visual observations have been made at the springs on numerous occasions over the last decade using night vision equipment (M. Buettner, personal observation, cited in USFWS 2008). During these observations, spawning was noted in water depths of approximately 0.5 feet and greater. In 1995, the Klamath Tribes conducted an intensive spawning survey at Sucker Springs (Klamath Tribes 1995). This survey documented spawning in water depths of 0.6 to 3.8 feet. Spawning occurred primarily at two locations, an inshore shallow area near the major spring discharge and a deeper area starting about 30 feet out from the shoreline. In the inshore spawning area, the 50 percent cumulative frequency depth was 1.8 feet, with half the measurements in deeper water and half in shallower water.

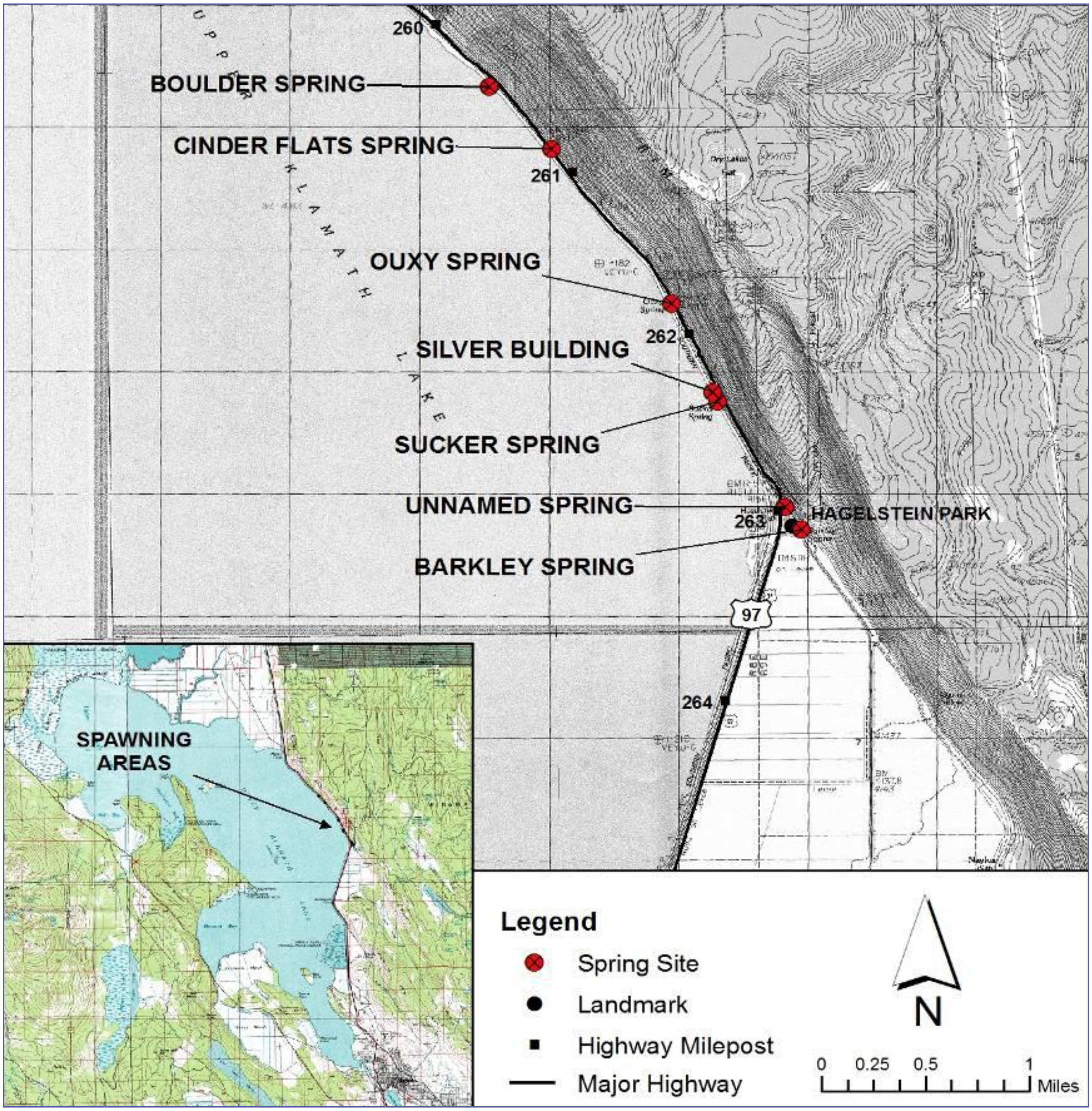

Figure 6-1. Predominantly Lost River suckers, and a small number of shortnose suckers, spawn at several locations along the eastern shoreline of UKL during spring months each year.

For the offshore spawning area, the 50 percent cumulative frequency was 2.9 feet. Over 90 percent of the sucker embryos were found at depths of 1.0 to 3.5 feet. A greater depth of water (higher lake surface elevation) at the shoreline spawning areas may increase security for spawning fish, the size of spawning areas, the opportunity (both behavioral and quantity) for spawning, and the likelihood of greater productivity for critical early life periods (USFWS 2008a).

Lake elevation plays an important role in the availability of the shoreline spawning habitats (USFWS 2008a). Based on 1999 bathymetric surveys at shoreline spawning areas, Silver

Building Springs, Ouxy Springs, and Cinder Flats are at different lake bottom elevations, indicating that these springs become inundated to at least a 1.0-foot depth at various lake surface elevations. Average percent inundation of spawning habitat to a depth of at least one foot at Cinder Flat, Ouxy, Silver Building, and Sucker Springs decreases from 100 percent at a full lake elevation of 4,143.3 feet to 73.8, 49.8, 30.2, and 13.8 percent at surface elevations of 4,142; 4,141; 4,140; and 4,139 feet, respectively (Reclamation 2002). At Sucker Springs, the lower extent of the spawning gravel is at an approximate elevation of 4,138.5 feet. At elevations 4,140; 4,141; 4,141.5; 4,142; and 4,142.5 feet, 33 percent, 53 percent, 63 percent, 77 percent, and 92 percent of the spawning substrate is inundated to a depth of at least one foot (approximate minimum preferred depth for spawning).

Past and current management of water in UKL has generally resulted in increasing lake levels during the winter and spring with the target of filling the lake during April or May (Reclamation 2002). Management of water in UKL has generally been such that at least 50 percent of the spawning habitat was inundated to a depth of at least one foot (USFWS 2008a). However, during past drought years, such as 1991, 1992, and 1994, lake surface elevations inundated very little of the shoreline spawning habitat (Reclamation 2001a).

A reduction in spawning habitat at the shoreline areas could encourage adult suckers to skip spawning or force them to spawn in confined areas. Concentrated spawning at the shoreline areas could interfere with incubation of previously deposited eggs by either dislodging or smothering fertilized eggs (USFWS 2008a). Little is known whether spawn skipping impacts individual adult suckers, it is possible that there are both beneficial and negative impacts to an individual that skips spawning. However, spawn skipping may cause a reduction of individuals and genetic material available to recruit into future adult populations.

Low surface elevations during months in which suckers spawn, typically March through June, impact the number of adult Lost River suckers that spawn at the shoreline spawning areas. During 2010, UKL surface elevation was low during the time at which suckers spawn (e.g., March through June). During 2010, lake elevation rose from 4,139.99 feet on March 1 to 4,141.25 feet on June 1 (USGS gauge 11507001, Reclamation datum). Recapture probability of marked adult Lost River suckers at the shoreline spawning areas in 2010 were about 13 to 14 percent lower for females and eight to nine percent lower for males than in previous years when lake elevations were higher during spawning (Janney 2012, pers. comm.). The lower recapture probabilities indicate that spawning either occurred without detection near the springs, or more likely, that up to 14 percent of female and up to nine percent of male Lost River suckers skipped spawning in 2010 (Janney 2012, pers. comm.).

Habitat for egg incubation and embryo development is similar to adult spawning habitat at the shoreline areas. However, egg and embryo survival at the shoreline spawning areas may not require a minimum one-foot depth inundation of these habitats. To date, no investigations have been conducted on the depth of water required for embryo development; however, the Klamath Tribes did observe over 90 percent of sucker embryos at Sucker Springs at depths of 1.0 to 3.5 feet (Reiser et al. 2001). This observation is likely more supportive of adult sucker site selection for spawning than it is related to a minimum depth required for sucker egg incubation.

Lake surface elevations that are stable or increasing during, and for several weeks following, spawning at the shoreline areas will prevent desiccation of fertilized eggs and developing embryo survival. Incubation of sucker eggs is approximately 10 to 14 days between egg deposition and about 17 to 21 days until larval sucker swim up from spawning gravels (Buettner and Scoppettone 1990). Spawning can occur at the shoreline areas from about March 1 through June 1 with peak spawning activity in April. Past and current management of water in UKL has generally resulted in increasing lake levels during the winter and spring with the target of filling the lake during April or May (Reclamation 2002).

The wetlands around the mouth of the Williamson River were surveyed prior to restoration of the Williamson River Delta (Dunsmoor et al. 2000). From this and other survey efforts, a relationship between lake elevation and the area of emergent vegetation near the Williamson River inundated to a depth of at least one foot was developed (Reiser et al. 2001, Reclamation 2002). As the lake decreases from spring into summer, the area of emergent vegetation available as larval sucker habitat also decreases (Figure 6-2).

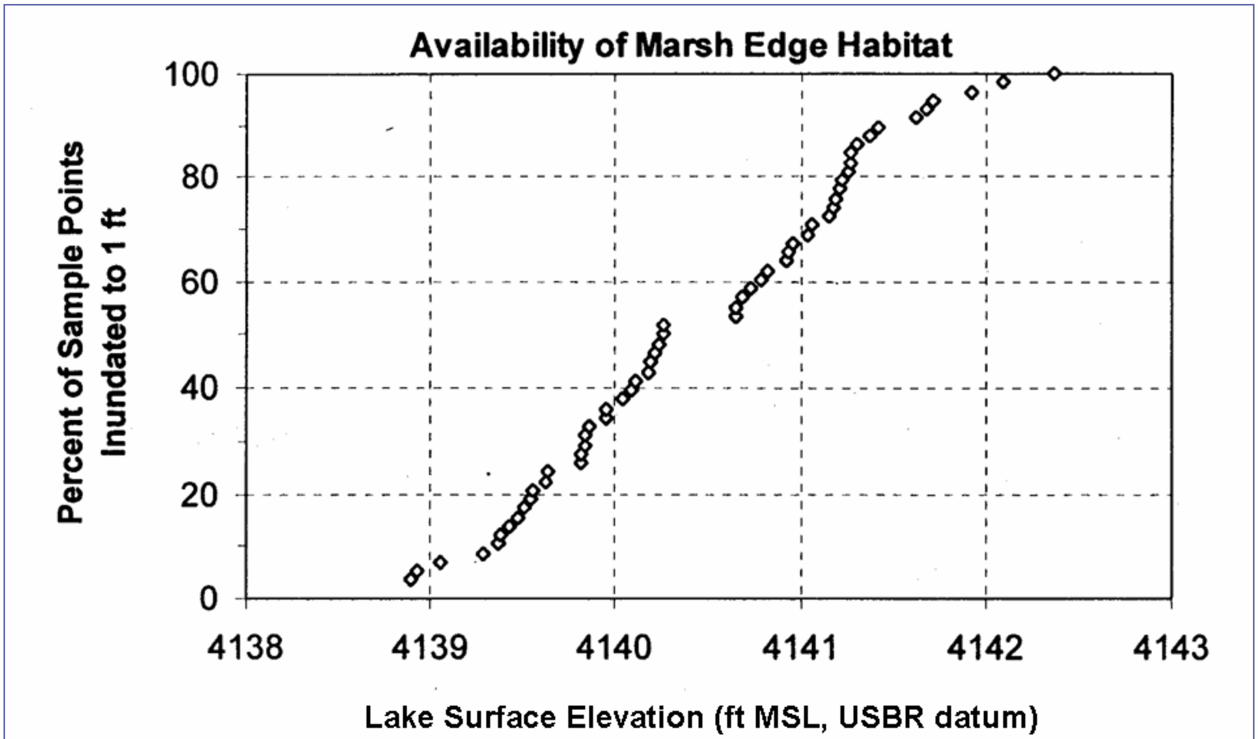

Figure 6-2. Availability of marsh edge habitat across Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) is based on percentage of sample points inundated to at least one foot water depth (from Reiser et al. 2001).

The relationship between lake surface elevation and emergent vegetation is likely similar for other wetland areas around UKL. The trend is also similar for the developing vegetation areas on the restored Williamson River Delta, which contributes additional shoreline areas of varying depth that are becoming colonized by wetland vegetation. Estimated potential emergent wetland habitat at the restored Williamson River Delta was based on data for the depth distributions of emergent vegetation in UKL and information on water-depth tolerances for wetland plants from published literature (Elseroad 2004). Based on a continuation of recent lake elevation management and topography in the delta, areas of potential emergent vegetation were identified (Elseroad 2004). Assuming that little or no emergent vegetation grows below an elevation of 4,139 feet, the area of potential emergent vegetation at the Williamson River Delta is likely a function of lake surface elevation above 4,139 feet (Table 6-2).

Prior to restoration, there were only about 15 acres of emergent wetlands near the Williamson River mouth (Dunsmoor et al. 2000). If only a fraction of the estimated 2,000+ acres of emergent vegetation becomes established, the restored delta represents significant increases in larval sucker habitat as compared to amounts present before restoration. Utilization of this habitat by larval suckers should result in increased survivorship and numbers of suckers at the earliest life history stage, especially if habitat has been a limiting factor for survivorship in UKL (Reclamation 2007).

Table 6-2. Acres of potential emergent vegetation habitat at the Williamson River Delta under different Upper Klamath Lake elevations are based on data in Elseroad (2004) and a geographic information system analysis of topographic data. Little or no emergent vegetation is expected below 4,139 feet.

UKL surface Elevation (feet above mean sea level; North American Vertical Datum 88 and Reclamation datum in parentheses)	Tulana Emergent Vegetation (acres)	Goose Bay Emergent Vegetation (acres)	Total Williamson River Delta Emergent Vegetation (acres)
4,145.03 (4,143)	1,080	1,560	2,640
4,144.03 (4,142)	850	1,390	2,240
4,143.03 (4,141)	580	1,080	1,660
4,142.03 (4,140)	290	550	870
4,141.03 (4,139)	0	0	0

Older juvenile and adult suckers utilize offshore areas of UKL at specific depths (Peck 2000, Banish et al. 2007, 2009). New bathymetric information from the Navionics survey improves our understanding of the relationship between lake surface elevation and available open water habitat of particular depths due to better resolution in mapping the lake bottom. In 2008, a bathymetric survey of UKL was conducted using boat-mounted acoustic Doppler by Navionics. This survey, with transects spaced approximately 20 feet apart, contained more detail than previous efforts and indicated that UKL is deeper than previous surveys. The results of the survey were investigated and determined reliable with field data collected at the south and north ends of UKL. In 2009, the Williamson River Delta elevations were modeled, and, in 2010, a LiDAR survey of the UKL shoreline and associated wetlands was also conducted. Both the Delta and the shoreline surveys indicated that the Navionics data is reliable for UKL, and should be considered the best available information on UKL bathymetry.

During low DO events in UKL, adult suckers seek refuge areas from poor water quality, particularly Pelican Bay (Bienz and Ziller 1987, Buettner and Scoppettone 1990, Banish et al. 2007, 2009). Pelican Bay, Fish Banks, and Williamson River provide important refuge areas for older juvenile and adult suckers in UKL when water quality conditions degrade during late summer. Older juvenile suckers have been observed utilizing the Williamson River Delta area during summer (Burdick 2012a, 2012b) and adult suckers are more commonly associated with the Pelican Bay and Fish Banks areas (Banish et al. 2009). In 2003, Banish et al. (2009) observed adult suckers congregating at Fish Banks and other areas outside Pelican Bay as water quality, particularly DO, declined in late July. As water quality continued its impaired state into August, adult suckers entered and congregated in the channel that accesses Pelican Bay (Figure 6-3). Water depth in which suckers were observed was believed to be between one and two meters based on previous bathymetric data (Banish et al. 2009).

Water depths in Pelican Bay can be six feet or less during the summer when water quality is most likely poor and access to the Bay could be across areas shallower than the Bay (USFWS 2008a). If adult suckers avoid depths less than six feet, low lake levels in late summer could pose an unquantified risk to them if they are reluctant to enter shallow areas with better water quality (USFWS 2008a).

Both Lost River and shortnose suckers reside downstream of UKL (NRC 2004). The 1.2-mile-long Link River is primarily used as a migration corridor for suckers moving between Keno Reservoir and UKL (Reclamation 1996, USFWS 2002). Juvenile suckers have been sampled in Link River throughout the year, suggesting that this area may provide some rearing habitat (Reclamation 1996, 2000). Below the Link River, larvae and age-0 suckers were most abundant in Link to Keno Impoundment Reach of the Klamath River; juvenile and adult suckers were rare (Terwilliger et al. 2004, Reithal 2006). Small numbers of Lost River and shortnose suckers were collected in both 2001 and 2002 (PacifiCorp 2004). Survey efforts in the 1990s captured only a few juvenile and adult Lost River and shortnose suckers during limited sampling in the Link to Keno Impoundment Reach (Hummel 1993, ODFW 1996). In recent years, Reclamation has captured and tagged a total of 1,136 shortnose suckers and 285 Lost River suckers during ongoing sampling for suckers in Lake Ewauna since 2008 (Kyger and Wilkens 2011a, 2012 draft).

Maximum water levels in the natural lake controlled by Keno Reef were similar to the currently managed Reservoir elevation (Weddell 2000). Historically, the Klamath River and Lower Klamath Lake above Keno Reef fluctuated in elevation more than they do now (typically 1 to 1.5 feet). This annual fluctuation provided conditions that supported a large emergent wetland fringe to Lake Ewauna/Klamath River that is absent today (USFWS 2008a). An agreement between PacifiCorp and Reclamation specifies that the maximum water surface elevation of Keno Reservoir remains relatively constant most of the year (PacifiCorp 2012).

However, about every one or two years, aside from the agreement with Reclamation and at the request of irrigators, PacifiCorp draws the Reservoir down about feet over a period of 24 hours (drawdown rate of less than one inch per hour) for one to four days in March or April, so that irrigators can conduct maintenance on their pumps and clean out their water withdrawal systems before the irrigation season (PacifiCorp 2012). The normal maximum water surface of the Link to Keno Impoundment Reach is 4,086.5 feet in elevation.

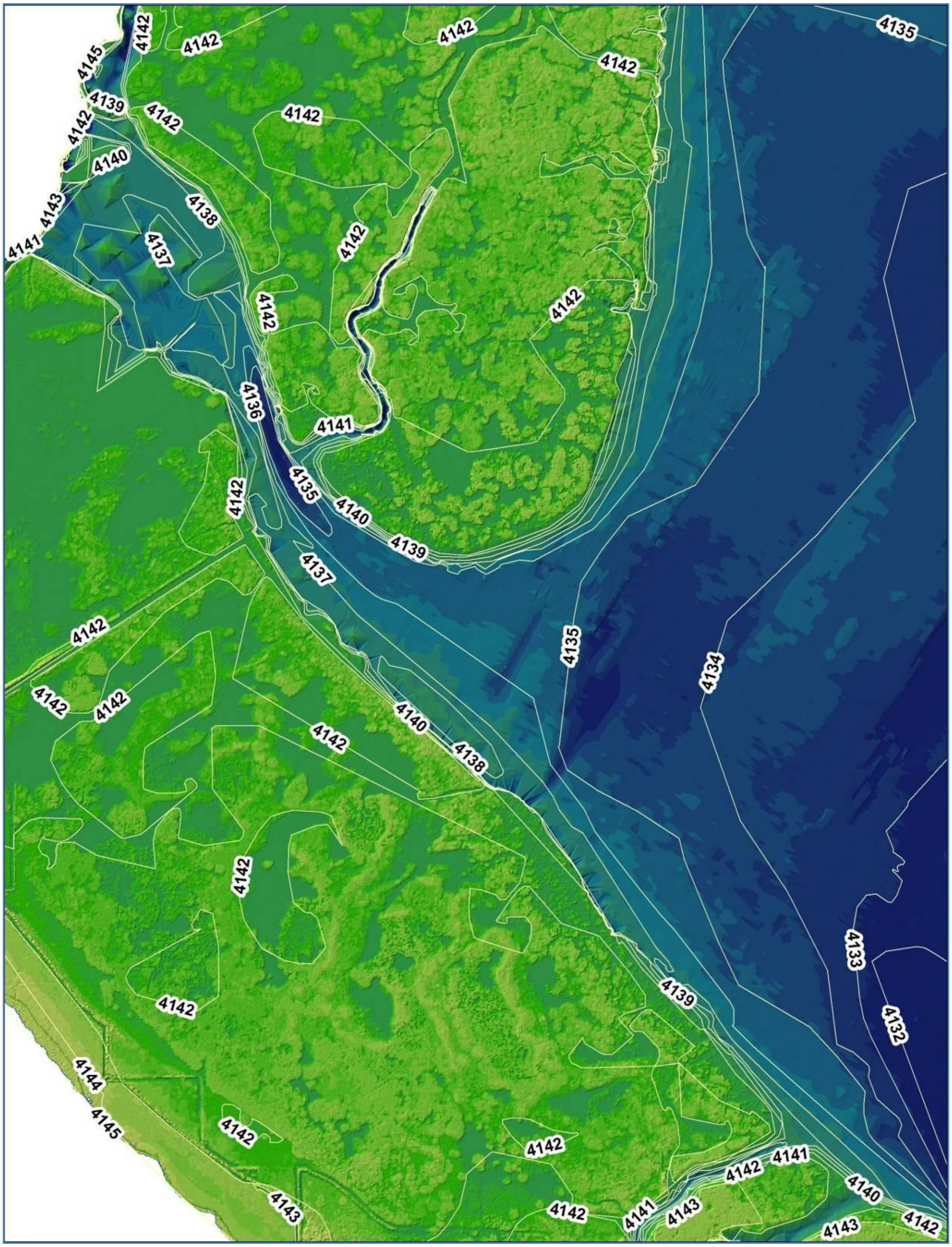

Figure 6-3. General lake bottom elevation of the access channel to Pelican Bay and the Fish Banks area to the east of Pelican Bay is about 4,135.53 feet (North American Vertical Datum 88; or about 4,133.5 feet in Reclamation datum). The terrain model was created in 2012 from multiple sources and contours were generalized and hand-edited to reduce data artifacts.

6.2.1.2.2. Habitats in the Lost River Recovery Unit

Sucker habitat requirements are less understood for endangered sucker populations in the Lost River Basin, such as Clear Lake and Gerber Reservoirs, than in UKL, particularly at early life history stages. Habitats utilized by suckers in UKL, such as emergent vegetation, are generally scarce or absent along the shorelines of Clear Lake and Gerber Reservoirs (Reclamation 2002). However, some vegetative cover may be provided to larval suckers at Clear Lake and Gerber Reservoirs by flooded annual grasses and herbs remaining from the previous growth season on the lake bed prior to lake level rising in the spring (USFWS 2002). Also, the lower reaches of the primary spawning tributaries do provide some emergent and submerged shoreline vegetation during the spring and early summer when larvae would be present in the Lost River Basin Reservoirs (USFWS 2002). Additional cover may be provided by high turbidity (USFWS 2008a). Juvenile suckers, although older and larger than larval suckers, occupy shoreline habitats in these systems that lack shoreline emergent vegetation (Scoppettone et al. 1995, Reclamation 2001a).

Clear Lake

Low lake levels associated with prolonged drought is the primary threat to Lost River and shortnose suckers in Clear Lake Reservoir (USFWS 2007a, 2007b, 2008a). Clear Lake Reservoir is particularly vulnerable to drought because net inflows are relatively low as a result of a small watershed, low annual precipitation, diversions in the upper watershed, and substantial evaporation and seepage from its large surface area (USFWS 2007a, 2007b, 2008a). During a drought, elevation in Clear Lake can decrease substantially and following a drought lake surface elevations are sometimes slow to recover, persisting for multiple years such as the events in the 1920s and 1930s (USFWS 2008a). Record low lake levels occurred in Clear Lake in the 1930s and again in 1992 (USFWS 2008a). In the 1930s, low water levels persisted for eight years, reaching a minimum elevation of 4,514 feet, which is just one foot above the lowest elevation contour line shown on bathymetric maps (Reclamation 1994a). In 1992, Clear Lake reached a low level of 4,519.4 feet after six years of drought, and the east lobe of the lake was dry, except for a small pool near the dam (USFWS 1994).

Low lake levels can adversely affect Lost River and shortnose suckers by limiting access to Willow Creek (USFWS 2002, 2008a). A minimum lake level of about 4,524 feet is believed necessary to provide access to the creek during spring months (Reclamation 2003, USFWS 2008a). Access to Willow Creek is important because there are no other known spawning areas in Clear Lake. Lack of access to Willow Creek is likely to prohibit or reduce sucker reproduction at Clear Lake in a given year. A survey for hydrologic connectivity of lower Willow Creek, the channel between the east lobe of Clear Lake and Clear Lake Dam, and the channel between the east and west lobes of Clear Lake, indicated that a hydrologic control point at an elevation of 4,521.7 feet exists between the east lobe and the mouth of Willow Creek (Sutton and Ferrari 2010). This information suggests a "disconnection" occurs between surface waters of the east lobe and the dam including the mouth to Willow Creek when the east lobe of Clear Lake drops below an elevation of about 4,522.0 feet (Sutton and Ferrari 2010). At a lake elevation of 4,524.0 feet, this hydrologic control is inundated with approximately 2.3 feet of water.

Detections of PIT (Passive Integrated Transponder)-tagged adult suckers in Willow Creek in comparison to lake elevations (gauge at the dam) indicates that sucker movement into Willow Creek from 2006 through 2011 appears to be a function of lake elevation of about 4,524.0 feet and Creek discharge as represented by the increasing slope of surface elevation (Figure 6-4). In years with relatively large numbers of tagged suckers detected in Willow Creek, there was also a rise in lake elevation. Rising elevation at Clear Lake indicates relatively high total inflow through all tributaries to Clear Lake, of which Willow Creek is the largest. In years with relatively little inflow, as indicated by no or little change in lake elevation, there were relatively low numbers of tagged suckers detected in Willow Creek regardless of lake elevations near 4,524.0 feet (e.g., 2009 and 2010) or at a lake elevation above 4,524.0 feet (e.g., 2007; Figure 6-4). The number of PIT-tagged adult suckers detected in Willow Creek during 2007 was lower than during 2006 and 2008, apparently because spawning runs in 2007 decreased in magnitude and duration (lasting only about two weeks).

For Lost River and shortnose suckers, the magnitude and duration of the spawning runs increased in years with higher inflows to Clear Lake Reservoir, and peaks in the runs corresponded with periods of increasing water temperature. These results are similar to observations in the Williamson and Sprague Rivers for sucker populations in UKL, although suckers in Clear Lake initiate migration at colder water temperatures (Barry et al. 2009).

The exceedances on hydrologic data from Clear Lake Reservoir for the period from 1903 to 2012 indicate that surface elevations are typically above 4,520.6 feet at the end of September (Table 6-3). Further review of the hydrologic data from Clear Lake Reservoir indicates that surface elevation was at or below 4,520.6 feet at the end of September during eight years, each of which occurred after construction of Clear Lake Dam in 1910 (Appendix 6A; 1931 to 1935, 1992, 2004, and 2010). Of those eight years, five were during the 1930s, a decade of historic drought in North America. In two of the three remaining years that surface elevations were at or below 4,520.6 feet by the end of September, surface elevations rose to above 4,524.0 feet by the end of March in the following year (Appendix 6A; 1992 and 2010).

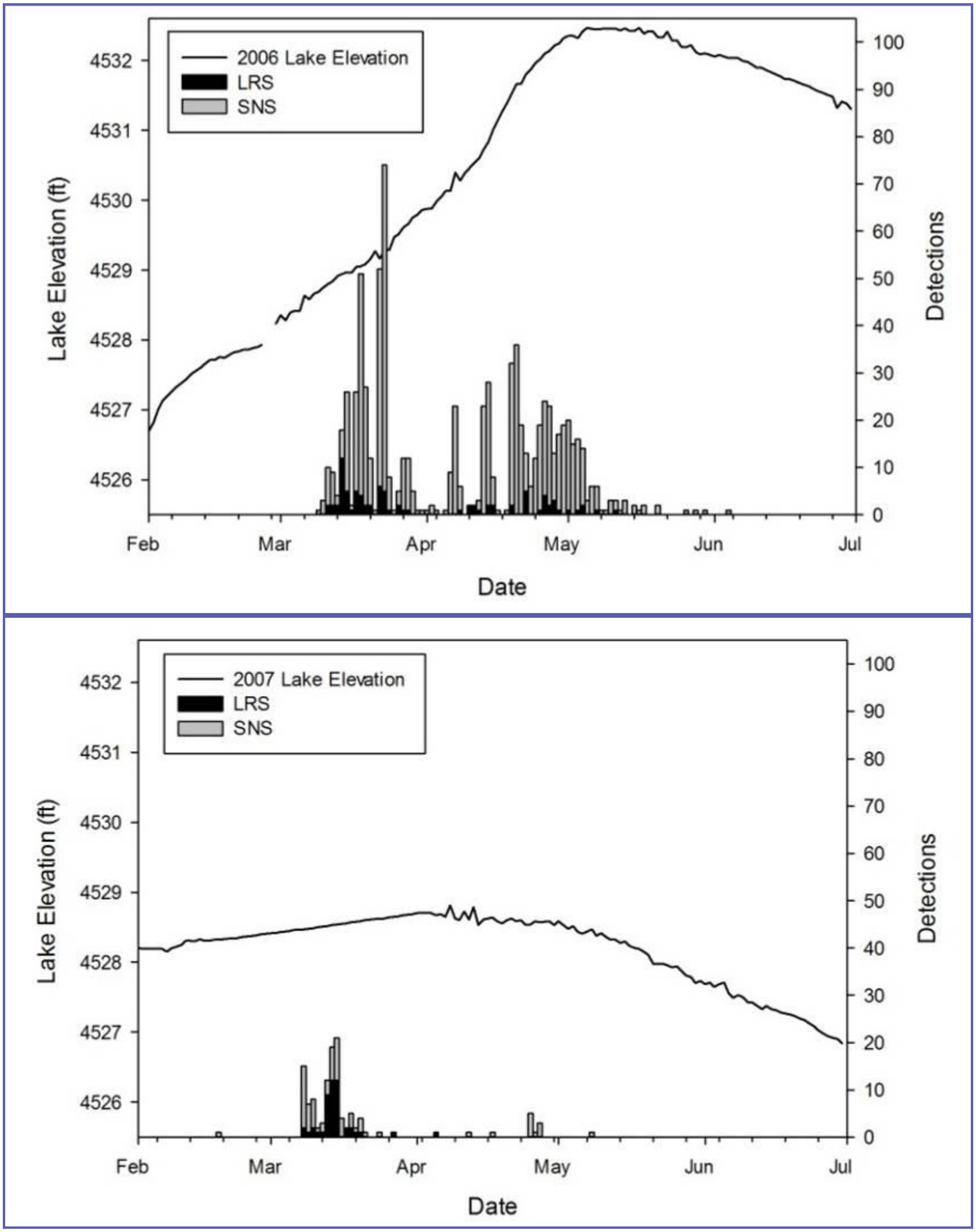

Figure 6-4. Plots of Clear Lake surface elevation from the gauge in the east lobe near the dam and adult suckers tagged with Passive Integrated Transponders that were detected in Willow Creek during each year 2006 through 2011. Numbers of tagged adult suckers detected each year was variable. Please note axes scale changes between plots on the following pages. Data on sucker detections in Willow Creek is courtesy of USGS, Klamath Falls Field Station.

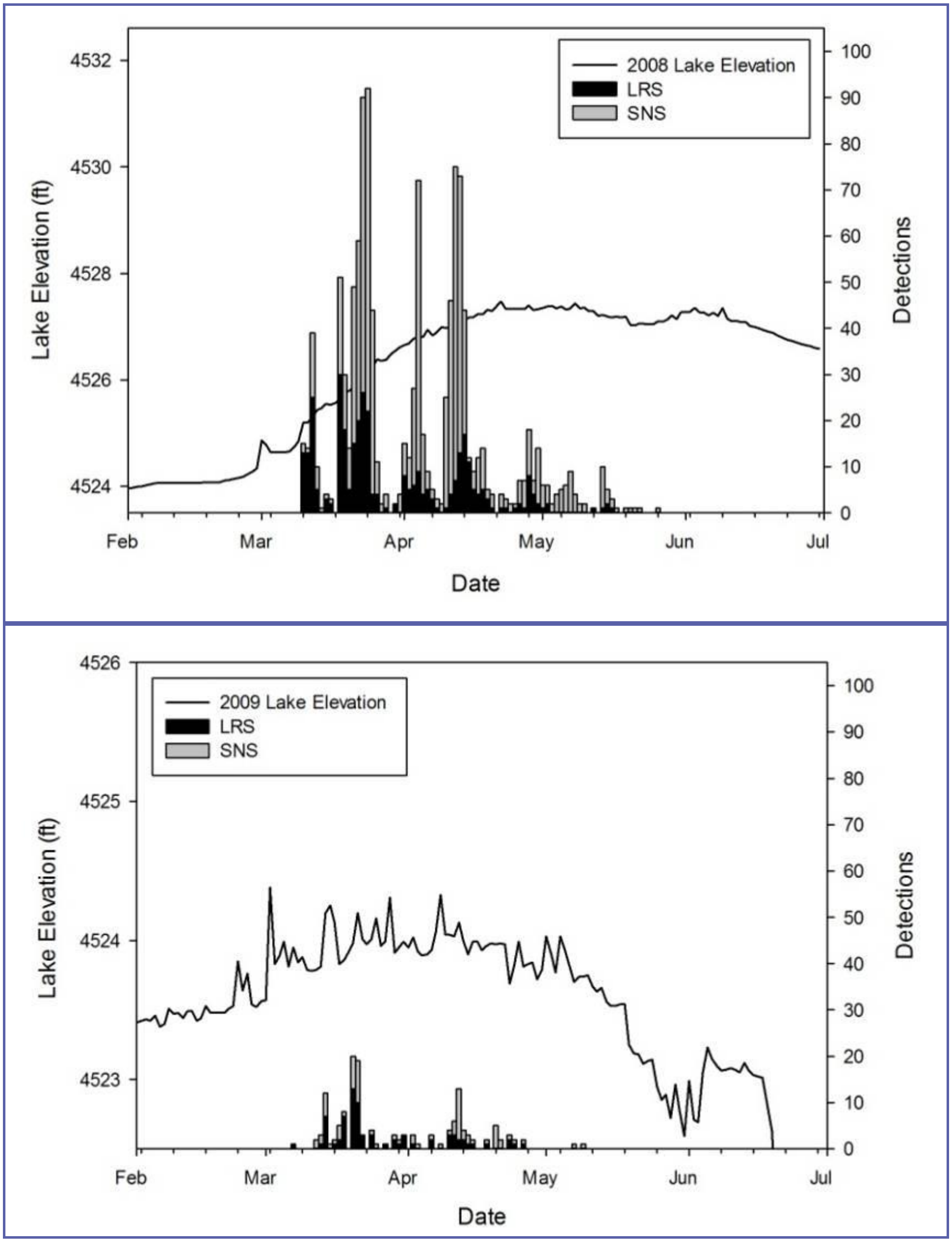

Figure 6-4 (continued). Plots of Clear Lake surface elevation from the gauge in the east lobe near the dam and adult suckers tagged with Passive Integrated Transponders that were detected in Willow Creek during each year 2006 through 2011. Numbers of tagged adult suckers detected each year was variable. Please note axes scale changes between plots. Data on sucker detections in Willow Creek is courtesy of USGS, Klamath Falls Field Station.

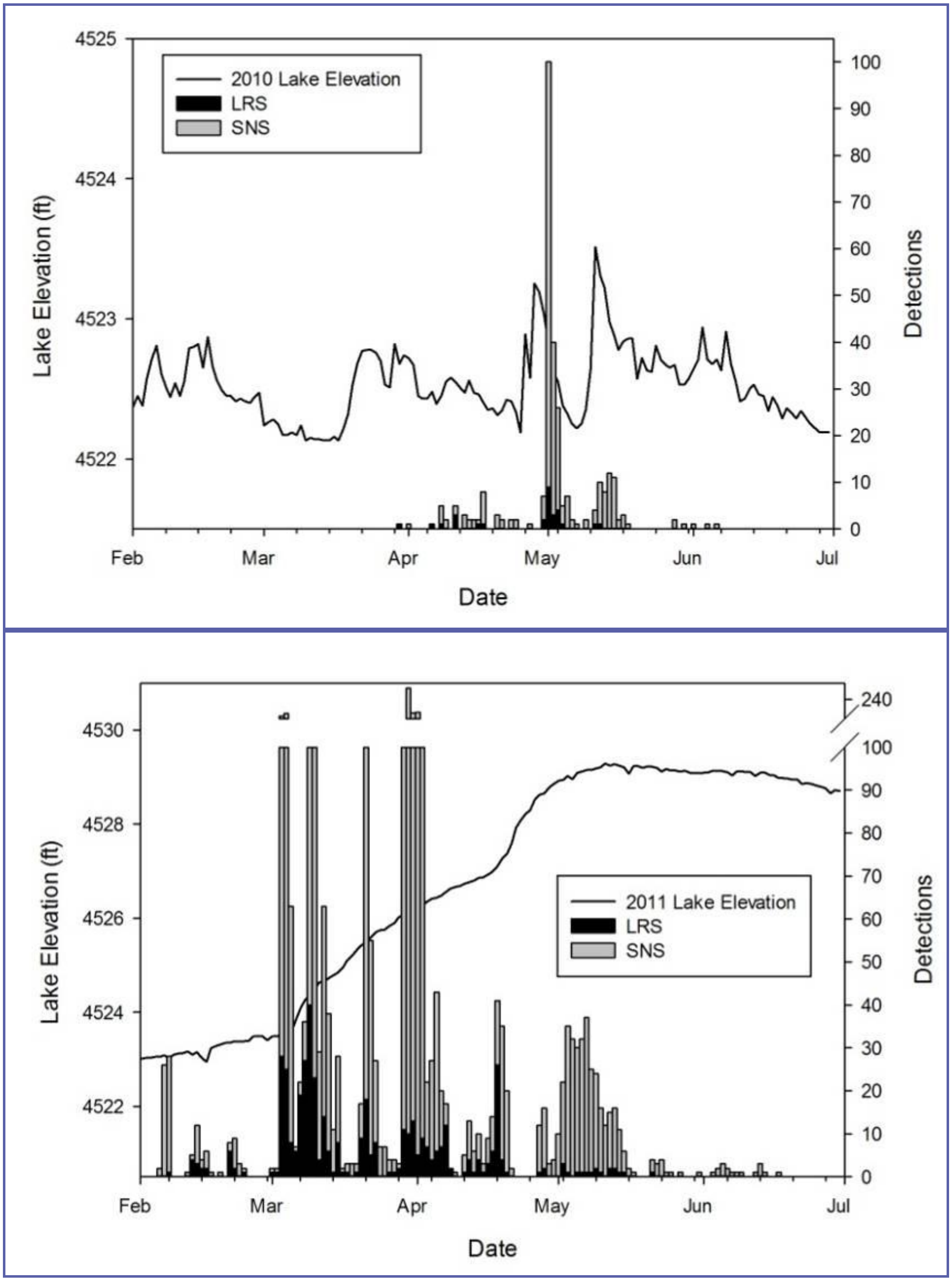

Figure 6-4 (continued). Plots of Clear Lake surface elevation from the gauge in the east lobe near the dam and adult suckers tagged with Passive Integrated Transponders that were detected in Willow Creek during each year 2006 through 2011. Numbers of tagged adult suckers detected each year was variable. Please note axes scale changes between plots. Data on sucker detections in Willow Creek is courtesy of USGS, Klamath Falls Field Station.

At low lake levels, the size of Clear Lake Reservoir decreases substantially. The area-capacity relationship of Clear Lake shows that at an elevation of 4,520.6 feet, the surface area of the lake is about 41,150 acres, and as the surface elevation decreases to 4,513.0 feet, the surface area is nearly zero (USFWS 2008a). Based on bathymetry of Clear Lake, the east lobe is nearly dry at an elevation of about 4,520.0 feet. At lake elevations less than 4,520.0 feet, the remaining sucker habitat in Clear Lake is most likely the west lobe and the western portion of the channel between the two lobes (Figure 6-5).

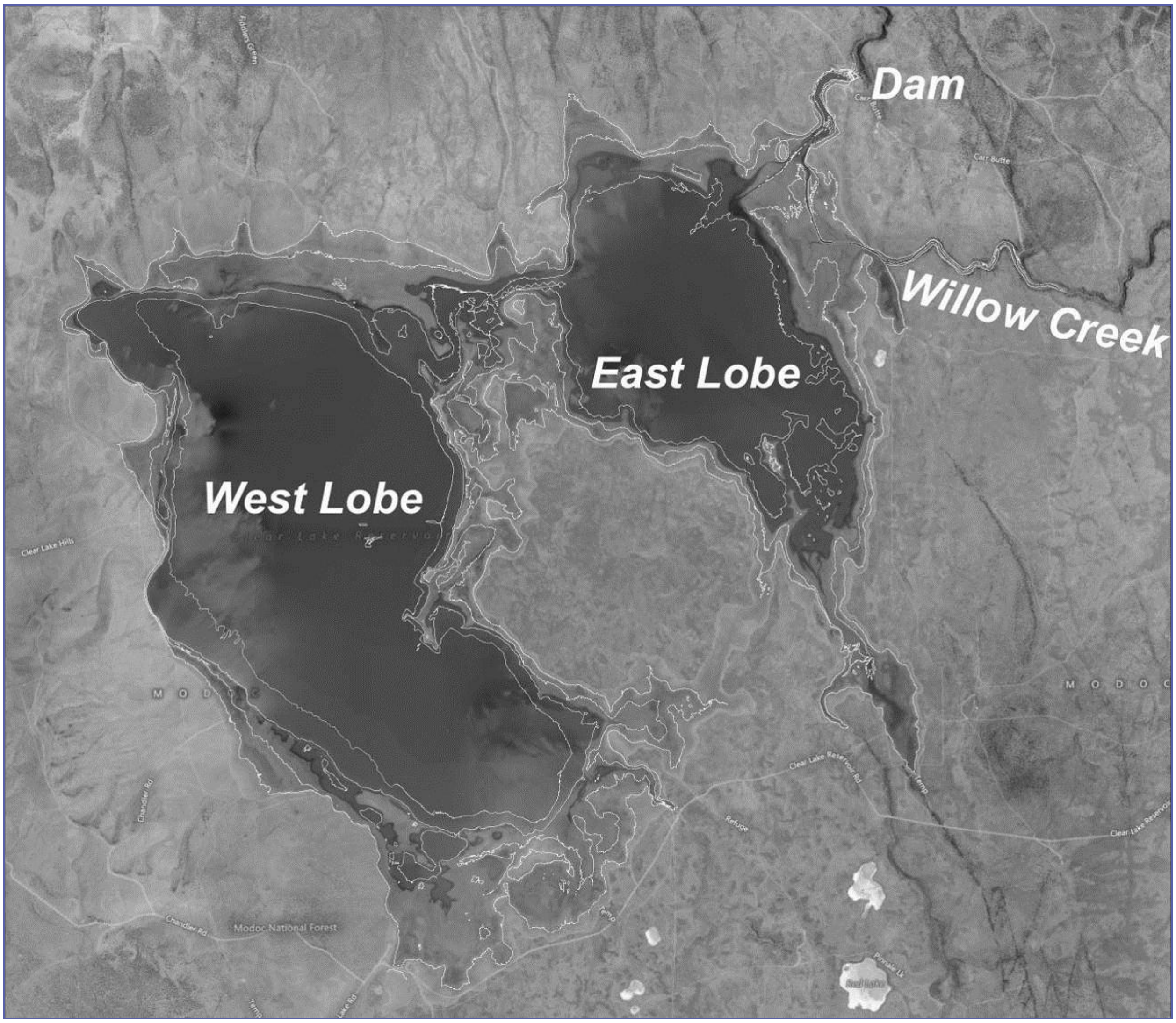

Figure 6-5. Aerial image of Clear Lake Reservoir showing the locations of Clear Lake Dam, Willow Creek, the two lobes of the Reservoir, and channels between the lobes and between the Reservoir and the Dam. Representative bathymetry of the lake is superposed on the image.

Table 6-3. Exceedances of Clear Lake Reservoir surface elevations (feet above mean sea level; Reclamation datum) for the period of 1903 through 2012. The original Clear Lake Dam was constructed in 1910.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	4,519.78	4,519.74	4,519.76	4,519.86	4,521.47	4,522.75	4,523.03	4,522.57	4,521.18	4,520.44	4,520.50	4,519.42
90%	4,521.61	4,521.82	4,522.09	4,522.43	4,523.04	4,524.32	4,525.05	4,524.76	4,523.80	4,522.82	4,521.60	4,521.44
85%	4,521.96	4,522.23	4,522.94	4,523.27	4,524.33	4,525.90	4,526.04	4,525.69	4,524.72	4,523.42	4,522.10	4,521.84
80%	4,523.30	4,523.35	4,524.20	4,524.61	4,525.37	4,526.58	4,527.33	4,526.84	4,525.94	4,524.74	4,523.60	4,522.96
75%	4,524.14	4,524.24	4,524.89	4,525.37	4,526.00	4,527.15	4,528.51	4,527.73	4,527.19	4,526.06	4,524.90	4,524.15
70%	4,524.60	4,524.93	4,525.95	4,526.26	4,526.71	4,527.70	4,528.85	4,528.75	4,527.83	4,526.48	4,525.49	4,524.80
65%	4,525.80	4,525.95	4,526.54	4,526.99	4,527.37	4,528.69	4,529.60	4,529.34	4,528.67	4,527.71	4,526.65	4,526.16
60%	4,526.71	4,526.70	4,526.90	4,527.52	4,528.30	4,529.79	4,530.94	4,530.55	4,529.90	4,528.78	4,527.74	4,527.08
55%	4,527.25	4,527.40	4,528.04	4,528.63	4,529.63	4,530.60	4,531.52	4,531.12	4,530.30	4,529.12	4,528.17	4,527.50
50%	4,528.30	4,528.31	4,528.64	4,529.16	4,530.41	4,531.28	4,532.28	4,532.05	4,531.30	4,530.38	4,529.70	4,529.06
45%	4,529.45	4,529.36	4,529.78	4,530.41	4,531.32	4,531.83	4,533.04	4,533.00	4,532.00	4,531.10	4,530.37	4,529.68
40%	4,530.11	4,530.09	4,530.48	4,531.15	4,532.09	4,533.44	4,533.95	4,533.47	4,532.98	4,532.00	4,531.20	4,530.37
35%	4,530.85	4,531.00	4,530.97	4,531.78	4,532.93	4,533.77	4,534.38	4,534.40	4,533.76	4,532.52	4,531.64	4,531.00
30%	4,531.36	4,531.38	4,531.80	4,532.12	4,533.56	4,534.26	4,535.33	4,534.70	4,533.97	4,533.30	4,532.14	4,531.54
25%	4,532.41	4,532.47	4,532.29	4,533.63	4,533.98	4,535.14	4,536.24	4,535.83	4,535.06	4,534.06	4,533.35	4,532.71
20%	4,533.25	4,533.22	4,533.36	4,534.15	4,534.96	4,535.82	4,537.00	4,536.56	4,536.02	4,535.30	4,534.20	4,533.42
15%	4,533.58	4,533.68	4,533.88	4,534.45	4,535.79	4,536.92	4,537.88	4,537.62	4,536.64	4,535.65	4,534.64	4,534.00
10%	4,534.16	4,534.06	4,534.27	4,535.13	4,536.26	4,538.16	4,538.48	4,537.86	4,537.30	4,536.20	4,535.20	4,534.48
5%	4,535.00	4,534.95	4,535.85	4,536.16	4,537.42	4,538.90	4,539.26	4,539.10	4,538.55	4,537.50	4,536.34	4,535.64

Suckers concentrated in shallow water could experience increased incidences of disease, parasitism (especially lamprey), and bird predation (USFWS 2008a). It is also reasonable to assume that the resulting high densities of fish could deplete the remaining food supply, causing additional stress and possible mortality. In 1992, when Clear Lake elevation reached a minimum of 4,519.4 feet in October, suckers showed signs of stress by the following spring including low body weight, poor development of reproductive organs, reduced juvenile growth rates, and high incidence of external parasites and lamprey infestation (Reclamation 1994a). Overall fish body conditions were improved with increased body weight and fewer external parasites and lamprey wounds at higher lake levels in 1993 to 1995 (Scoppettone et al. 1995).

Periodic low inflows and combined high seepage and evaporative losses may result in relatively low surface elevations at Clear Lake Reservoir as has been experienced in the past (Appendix 6A). Given the natural, sporadic hydrology at Clear Lake, inflows and surface elevations will need to be carefully monitored to ensure that they do not drop below minimum requirements, especially during multi-year droughts. During drought conditions the lake level will continue to decline as a result of evaporation and seepage, even without irrigation releases from the Reservoir. Estimated April through October evaporative and seepage losses were 43,500 AF from 1986 through 2008 (Reclamation, unpublished data). During the same period, irrigation releases from Clear Lake Dam averaged about 38,000 AF from April through October. Estimated evaporation and seepage was calculated from change in lake surface elevation, the area capacity curve for Clear Lake, in addition to the measured irrigation releases at the dam.

Prolonged duration of low inflows and relatively high losses due to evaporation and seepage results in a significant reduction in lake surface area and depth, such as what was observed from 1931 through 1935, and more recently in the early 1990s. However, it should be noted that suckers survived the lowest lake levels ever recorded at Clear Lake in the 1930s (e.g., surface elevation of 4,514.4 feet at the end of October 1934), and thus sucker populations can exhibit considerable resilience (USFWS 2008a).

Gerber Reservoir

Lost River suckers have not been identified as occurring in Gerber Reservoir. Use of the generic term “sucker” in Gerber Reservoir sections refers only to shortnose suckers. The primary threat to shortnose sucker populations in Gerber Reservoir is likely an extended, multiple-year drought which would likely result in low lake levels that could initiate a fish die-off during the late summer and fall or during prolonged ice cover conditions in the winter (USFWS 2008a).

Shoreline spawning by shortnose suckers has not been observed in Gerber Reservoir. Adult spawning principally occurs in Barnes Valley and Ben Hall creeks. Access to these creeks requires a minimum surface elevation of about 4,805.0 feet during February through May (USFWS 2008a). During very dry years both Barnes Valley and Ben Hall creeks typically have low spring flows that may not provide adequate upstream passage for spawning adults regardless of lake elevations (Reclamation 2001a). Although surface elevations at the end of September have been observed below the proposed minimum elevation of 4,798.1 feet in 5 years from the Period of Record at Gerber Reservoir (1931, 1960, 1961, 1991, and 1992), surface elevations of at least 4,805.0 feet were reached the following spring by the end of March (Table 6-4; Appendix 6B).

Summer surface elevations at Gerber Reservoir less than 4,800.0 feet significantly reduce juvenile and adult sucker habitat and are likely to result in increased competition for food, higher predation, and reduced fitness due to parasites and disease (Reclamation 2002, USFWS 2008a). Surface elevations below 4,800.0 feet are infrequent at Gerber Reservoir (Table 6-4). At 4,800.0 feet, the surface area of Gerber Reservoir decreases to about 750 acres. Surface elevations at Gerber Reservoir were below 4,800.0 feet in five years within the Period of Record (Appendix 6B; 1931, 1960 to 61, and 1991 to 92). Only in 1991 and 1992, were surface elevations below 4,800.0 feet observed persisting for longer than one or two months. At a surface elevation of 4,815.0 feet, there are about 2,000 surface acres with adequate depth to support adult suckers. During the period of 1986 through 2004, irrigation releases measured through Gerber Dam were 31,400 AF from April through October; and evaporation and seepage were estimated at 17,100 AF for the same periods (Reclamation, unpublished data).

Gerber Reservoir could experience hypoxic conditions if ice covered the surface for several months. In October 1992, the water surface elevation of Gerber Reservoir reached a minimum of 4,796.4 feet before the onset of a prolonged and cold winter. No winter fish die-offs were observed (USFWS 2008a). Observations made of shortnose suckers during the summer of 1992 and following the winter of 1992 to 1993, showed signs of stress including low body weight, poor gonad development, and reduced juvenile growth rates, but there was no mass mortality (Buettner 2005, pers. comm. cited by USFWS 2008a).

Tule Lake

Tule Lake NWR is within the Project. This refuge was established by an executive order dated 1928. The refuge supports many fish and wildlife species and provides suitable habitat and resources for migratory birds of the Pacific Flyway. Portions of the refuge are also used for agricultural purposes. The refuge receives water indirectly from Project facilities in the form of return flow and drainage (Reclamation 2007). Sumps 1A and 1B are refuge facilities that are managed to meet flood control and wildlife needs, including the needs of endangered suckers. Reclamation, through a contract with TID, manages deliveries from the sumps and pumping from D-Plant to aid Tule Lake NWR in maintaining the elevations necessary in the sumps to meet wildlife needs and requirements (Reclamation 2007).

Both Lost River and shortnose suckers reside in Sump 1A of Tule Lake. The current numbers of suckers in Tule Lake sumps are relatively small, probably in the low thousands of individuals, and dominated by adults (Hodge and Buettner 2007, 2008, 2009). Reclamation has operated seasonal surface elevations in Tule Lake Sump 1A consistent with the April 2008 BO (USFWS 2008a). Surface elevations in Sump 1A have been maintained for a minimum elevation of 4,034.0 feet from October 1 through March 31 and a minimum elevation of 4,304.6 feet from April 1 through September 30 each year since the 1992 BO (USFWS 1992).

Table 6-4. Exceedances for end of the month surface elevations at Gerber Reservoir 1925 through 2012.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	4,798.05	4,798.74	4,800.74	4,799.67	4,804.88	4,809.12	4,810.01	4,809.55	4,808.07	4,804.96	4,801.62	4,798.19
90%	4,802.88	4,804.24	4,805.64	4,805.18	4,807.68	4,813.37	4,815.94	4,816.35	4,813.32	4,809.07	4,805.56	4,802.46
85%	4,804.43	4,805.45	4,808.18	4,808.69	4,810.75	4,815.16	4,818.85	4,817.76	4,815.49	4,811.40	4,807.90	4,804.22
80%	4,806.57	4,807.08	4,809.02	4,811.80	4,812.72	4,817.63	4,820.27	4,819.15	4,816.50	4,812.52	4,809.08	4,806.05
75%	4,807.85	4,808.35	4,810.92	4,813.21	4,814.48	4,818.76	4,821.41	4,820.27	4,817.27	4,813.80	4,810.75	4,807.35
70%	4,809.58	4,810.46	4,811.77	4,814.04	4,815.82	4,820.14	4,822.45	4,820.94	4,818.56	4,815.09	4,812.69	4,809.43
65%	4,811.16	4,811.16	4,813.60	4,814.98	4,817.11	4,821.56	4,824.41	4,822.58	4,819.54	4,816.12	4,813.32	4,811.65
60%	4,812.63	4,812.65	4,814.75	4,816.38	4,817.78	4,822.64	4,825.28	4,823.55	4,821.55	4,818.75	4,815.71	4,812.74
55%	4,814.09	4,814.34	4,816.02	4,817.13	4,818.15	4,824.02	4,826.90	4,825.17	4,822.73	4,819.76	4,816.56	4,814.25
50%	4,815.44	4,815.62	4,817.66	4,817.75	4,820.02	4,824.89	4,827.70	4,826.56	4,824.10	4,820.81	4,818.00	4,815.70
45%	4,817.11	4,817.27	4,819.89	4,818.78	4,820.87	4,825.46	4,828.86	4,827.09	4,824.55	4,821.75	4,819.67	4,817.68
40%	4,818.14	4,818.36	4,820.40	4,820.43	4,821.75	4,826.09	4,829.59	4,828.14	4,825.96	4,822.87	4,820.65	4,818.82
35%	4,819.78	4,819.93	4,820.64	4,820.78	4,822.96	4,826.80	4,830.24	4,830.05	4,828.06	4,825.33	4,822.24	4,820.00
30%	4,820.57	4,820.62	4,821.52	4,821.64	4,823.40	4,828.28	4,831.68	4,830.80	4,829.57	4,826.44	4,823.31	4,820.77
25%	4,821.04	4,821.61	4,822.55	4,823.16	4,824.77	4,830.45	4,832.13	4,832.32	4,829.87	4,826.77	4,823.52	4,821.23
20%	4,821.93	4,822.59	4,823.05	4,824.11	4,826.16	4,831.69	4,834.18	4,833.04	4,830.52	4,827.46	4,824.53	4,822.51
15%	4,822.73	4,822.90	4,823.77	4,825.57	4,828.88	4,833.23	4,834.93	4,833.59	4,831.04	4,828.01	4,825.16	4,823.42
10%	4,823.96	4,823.90	4,825.16	4,827.13	4,831.03	4,834.64	4,835.50	4,834.59	4,832.34	4,829.28	4,826.68	4,824.41
5%	4,825.71	4,826.04	4,827.57	4,829.69	4,833.34	4,835.76	4,835.82	4,834.87	4,833.17	4,830.88	4,828.17	4,825.86

Historically, populations of suckers in Tule Lake migrated up the Lost River to spawn at Big Springs near Bonanza, Oregon (RM 45), and probably other shallow riffle areas with appropriate spawning substrate (Coots 1965, ISRP 2005). Access to spawning areas in the Lost River is blocked by upstream diversion dams including the Lost River Diversion Dam (1912), Anderson Rose Diversion Dam (1921), and Harpold Dam (1926). Currently, spawning migrations from Tule Lake are limited to a seven mile portion of the lower Lost River below Anderson Rose Diversion Dam (Hodge and Buettner 2008).

Reclamation and the USFWS have monitored endangered spawning runs from Tule Lake into the Lost River frequently since 1991 (Reclamation 1998, Hodge and Buettner 2007, 2008, 2009). Spawning is restricted to one riffle area below Anderson-Rose Dam. Spawning runs have occurred in years that Anderson-Rose Dam spills or releases water. Releases were required as provisions of earlier BOs (USFWS 1992, 2001). Minimum flows below Anderson Rose Dam were also previously required by the 2008 BO on Klamath Project Operations from 2008 to 2018. However, in 2009, the 2008 BO was amended, and those flows were no longer required as the USFWS stated in their letter dated January 6, 2009 (Reference # 8-10-09-F-070070, "…that habitat conditions in Tule Lake negatively influence recruitment far more than flows at Anderson Rose Dam, and therefore, we determined that Term and Condition #2 [flows below Anderson Rose Dam for spawning] is no longer necessary to minimize take of endangered suckers." In 2006 and 2007, the Service entered into an agreement with TID to provide releases during the spawning season (USFWS 2008a). Successful egg incubation and survival of larvae to swim-up has been infrequent in recent years (Hodge and Buettner 2008, USFWS 2008a). Only two juvenile suckers were captured in Tule Lake in 2007 suggesting recruitment continues to be very low (Hodge and Buettner 2008). Water levels in Tule Lake sumps have been managed according to criteria set in previous BOs (USFWS 2002). From April 1 to September 30, a minimum elevation of 4,034.6 feet was set in part to provide access to spawning areas below Anderson Rose Diversion Dam (USFWS 2008a).

Water depths of Tule Lake Sumps 1A and 1B are shallow (less than five feet deep). However, lack of deep areas in the sumps and the gradual sedimentation that appears to be occurring (USFWS 2002) is detrimental to older juvenile and adult suckers that require water depths greater than three feet to avoid predation by fish-eating birds, particularly pelicans (USFWS 2008a). The USFWS has been investigating options to restore deep water habitat including small-scale dredging and flooding existing agricultural lease lands that have subsided (Mauser 2007, pers. comm. cited in USFWS 2008a).

During severe winters with thick ice cover, only small, isolated pockets of water with depths greater than three feet exist, increasing the risk of winter die-offs (USFWS 2008a). However, the April 1 to September 30 minimum elevation of 4,034.6 feet was set in part to provide rearing habitat in Tule Lake (USFWS 2008a) and the October 1 to March 31 minimum elevation of 4,034.0 feet was set to provide adequate winter depths for cover and to reduce the likelihood of fish die-offs owing to low DO concentrations below ice cover (USFWS 2008a).

Lost River

Most of the Lost River hydrologic Basin consists of old lakebeds and ancient lake terraces surrounded by basaltic mountains. The Lost River historically was a "semi-terminal" system that traveled 76 RMs starting in the uplands surrounding Clear Lake and terminated at Tule Lake. Today, the Lost River hydrology consists of a complex system of canals, pumps, and dams used to manage irrigation delivery and tail-water runoff. Much of the water flowing through the modern day lower Lost River channel comes from UKL via A Canal. This water is reused many times by different users, the primary users being agriculture and two wildlife refuges. Water flowing in the current Lost River channel empties into the Tule Lake NWR and can be pumped to the Lower Klamath Lake NWRs before flowing to the Klamath River via the Klamath Straits Drain (Reclamation 2009).

The Lost River provides habitat for both Lost River and shortnose suckers. The system was historically home to large number of these suckers, but habitat within the Lost River is now largely fragmented and disconnected (Reclamation 2009). The Lost River currently supports a small group of shortnose suckers and very few Lost River suckers (USFWS 2002). Primarily shortnose suckers have been reported from throughout the drainage (Koch and Contreras 1973, Buettner and Scoppettone 1991, Shively et al. 2000b). However, the majority of both adults and juveniles are caught above Harpold Dam and to a lesser extent from Wilson Reservoir (i.e., impounded area behind the Lost River Diversion Dam; Shively et al. 2000b). Length-frequency distributions during the last survey efforts indicate that several year classes were represented within the Lost River (Buettner and Scoppettone 1991, Shively et al. 2000b).

Juvenile and adult suckers are found throughout the Lost River, but the majority of catches were made near Harpold Dam and upstream to Miller Creek (Shively et al. 2000b). The riverine reach from Clear Lake Dam to Malone Reservoir is not expected to support large numbers of sucker populations due to its high gradient and lack of deep pool habitat (Buettner 2005 cited in USFWS 2008a). Early sucker life history stages have been identified in the impounded waters at Malone, Harpold, and Lost River Diversion Dams (Shively et al. 2000b). Suckers were also identified in the reaches between these impoundments but in smaller numbers (Shively et al. 2000b).

Early sucker life history stages in the upper Lost River, from Wilson Reservoir up to Clear Lake Dam, are more numerous in the impounded areas, such as Lost River Diversion Dam and Malone Reservoir, and near natural inflow areas like Big Springs near Bonanza and the Miller Creek, than other areas sampled (Shively et al. 2000b). Adequate flow and habitat conditions are likely to occur during the spring and summer with higher river flows augmented by releases from Clear Lake and Gerber Reservoirs (USFWS 2008a). Irrigation releases typically start in April, and augment groundwater and low-elevation runoff in this river reach. Flows in the Upper Lost River are very low during the fall and winter. However, they do increase downstream from tributary and spring accretions (USFWS 2008a).

Early sucker life history stages in the lower Lost River, below Lost River Diversion Dam, likely originated from UKL and possibly from the Lost River above Lost River Diversion Dam (USFWS 2008a). However, there is a lack of suitable rearing habitat in the Lost River below the Lost River Diversion Dam and suckers likely move downstream into Tule Lake or J Canal (USFWS 2008a). Modifications to the Lost River channel have fragmented fish habitats; however, based on fish survey results, early life history stages occupy the impoundments in modest numbers (Shively et al. 2000b), indicating that habitat is available for these life history stages at these locations.

Sucker populations upstream and downstream of dams in the Lost River (e.g., Malone, Miller Creek, Harpold, Lost River Diversion Dam, and Anderson-Rose) are physically isolated and, therefore, genetic exchange between populations is restricted to occasional downstream exchange (USFWS 2008a). Hybridization between sucker species trapped below dams may also occur at higher frequencies, because spawning fish are restricted to small and perhaps inadequate spawning areas. This may be happening below Anderson-Rose Dam in the lower Lost River (USFWS 2002). However, there is no evidence that loss of genetic variability has occurred (Dowling 2005). The dams also prevent passage to potential spawning, rearing and water quality refuge habitat, and the return of suckers that move downstream back to upstream habitat (USFWS 2008a).

Sucker spawning habitat in the Lost River is limited. Spawning has been documented below Anderson-Rose Dam, in Big Springs near Bonanza, Oregon, at the terminal end of the West Canal as it spills into the Lost River near Lorella, Oregon, lower Miller Creek, and above Malone Reservoir (Reclamation 1998, 2001, Hodge and Buettner 2007, 2008, 2009, Sutton and Morris 2005).

There is little potential spawning habitat in the lower Lost River upstream of Anderson-Rose Dam because construction of the Lost River Diversion Dam inundated historic spawning habitat near Olene, and because of loss and degradation of historic spawning habitat at Big Springs near Bonanza and other locations in the Lost River and its tributaries (USFWS 2008a). Suckers that reside in the lower Lost River, particularly in the lake habitat of Wilson Reservoir, may attempt to spawn at Big Springs near Bonanza, Oregon. Harpold Dam, including several other small diversion dams near Bonanza, Oregon, is seasonally removed October until April each year, allowing fish passage during the fall, winter, and early spring. A modified vertical slot fish ladder at the Island Park (Bonanza) Diversion Dam was installed in 2006 to provide suckers with an opportunity to move above this dam during summer months.

Above Bonanza, Oregon, there is more opportunity for sucker passage in the Lost River. Shortnose suckers, presumably from the Lost River near Bonanza, spawn in the lower reaches of Miller Creek during April and May of some years (Reclamation 2001a, USFWS 2002). During a spill event in 1999 adult shortnose suckers were observed spawning in Miller Creek (USFWS 2008a). Spawning runs are infrequent during non-spill years and passage from the Lost River may be restricted by the shallow water depths at the mouth of Miller Creek (Reclamation 2001a, ISRP 2005).

Much of the fish habitat, including spawning habitats, in both the upper and lower Lost River is fragmented by the presence of dams and the irregular flows effecting adult sucker passage between habitats. Adult suckers have been observed attempting to spawn in the upper Lost River immediately upstream of Malone Reservoir (Sutton and Morris 2005). Adult suckers have also been observed spawning below Anderson-Rose Dam in the lower Lost River (Hodge and Buettner 2007, 2008, 2009).

6.2.1.3. Water Quality

In general, Lost River and shortnose suckers are relatively tolerant of degraded water quality conditions. They tolerate higher pH, temperature, and un-ionized ammonia concentrations, and lower DO concentrations than many other fishes (Saiki et al. 1999, Meyer and Hansen 2002, NRC 2004). Nonetheless, poor water quality events resulting in stressful and potentially lethal conditions for both Lost River and shortnose suckers periodically occur at each body of water within the Upper Klamath Basin. This section describes adverse water quality events at each body of water and the possible relationships between adverse water quality and other variables.

6.2.1.3.1. Water Quality: Upper Klamath Lake

Poor water quality in UKL is particularly associated with high abundance of the cyanobacteria *Aphanizomenon flos-aquae* (AFA; Buchanan et al. 2011). Core samples of bottom sediments indicate that AFA was not present in UKL prior to the 1900s (Eilers et al. 2004, Bradbury et al. 2004). Its appearance is believed to be associated with increases in productivity of the lake (NRC 2004). AFA now dominates the phytoplankton community from June to November, and because of the high concentrations of nutrients available, is able to reach seasonally high biomass levels that lead to highly degraded water quality (ODEQ 2002). These robust algal cycles affect adult Lost River and shortnose suckers as rapid algal decay depletes DO in the lake and creates anoxic conditions (Perkins et al. 2000b, ODEQ 2002, IMST 2003, NRC 2004, Wood et al. 2006). Such events can have lethal impacts to individual suckers (Perkins et al. 2000b) and can reduce the reproductive capacity of the populations by reducing the numbers of larger and more fecund females (Buchanan et al. 2011). Adverse water quality may also affect young suckers, but information is lacking regarding such effects (Buchanan et al. 2011).

It has been suggested that large-scale watershed development from the late-1800s through the 1900s has contributed to the current hypereutrophic condition in UKL (Bortleson and Fretwell 1993, Eilers et al. 2001, Bradbury et al. 2004, Eilers et al. 2004, Geiger et al. 2005). Accelerated sediment and nutrient loading to UKL consistent with land use practices in the Upper Klamath watershed (Eilers et al. 2004) have resulted in algae blooms of higher magnitude and longer duration (Kann 1998). These blooms have led to extreme water quality conditions (high pH, low DO, and high ammonia) that increase fish stress, negatively impact fish health and increase the size and frequency of fish die-offs (Perkins et al. 2000b, Wood et al. 2006, Kuwabara et al. 2007, Morace 2007). In recent decades, the lake has experienced serious water quality problems that have resulted in massive fish die-offs, as well as re-distribution of fish in response to changes in water quality (Buettner and Scoppettone 1990, Banish et al. 2007, 2009).

UKL waters contain only moderate levels of dissolved solids and alkalinity, but high concentrations of phosphorus, which in the warm, sunny conditions of the lake during summer support high production of phytoplankton, and especially of the nitrogen fixing cyanobacteria, AFA (Buchanan et al. 2011). The growth, senescence, and decay of massive amounts of the organism result in high pH and ammonia and low DO concentrations. Water quality in UKL is adequate for fish rearing during October through mid-June, but is poor from mid-June through September (Buchanan et al. 2011).

The massive blooms of AFA and the subsequent rapid decline (crash) can cause extremes in water quality including elevated pH, low DO concentrations (hypoxia), and elevated levels of un-ionized ammonia, which can be toxic to fish (Kann and Smith 1993, Kann and Smith 1999, Perkins et al. 2000b, Walker 2001, Welch and Burke 2001, Wood et al. 2006, Kuwabara et al. 2007, Morace 2007). In the process of rapid growth, algal biomass can form extremely dense blooms, which can vary in magnitude depending on the availability of growth-promoting conditions (Kann and Smith 1993, Kann and Smith 1999, Perkins et al. 2000b). During the same bloom conditions and following a bloom crash, particularly when coupled with high rates of nighttime respiration, DO can drop to levels that restrict fish growth and that can be lethal (Kann and Smith 1993, Kann and Smith 1999, Perkins et al. 2000b).

In addition, when dense algae blooms die off, the microbiological decomposition of the algae and organic matter in the bed sediment can further deplete DO and produce increased concentrations of ammonia (Kann and Smith 1993, Risley and Laenen 1999, Kann and Smith 1999, Perkins et al. 2000b, Walker 2001, Welch and Burke 2001, Wood et al. 2006, Kuwabara et al. 2007, Morace 2007). The potential for low DO concentration increases later in the growing season (July to September) when the algae blooms have crashed and considerable organic matter has accumulated in the sediments. During this same period, higher water temperature increases water column oxygen depletion rates as decomposition and respiration take place at a faster rate, while available oxygen tends to be lower because the oxygen concentration at saturation decreases as water temperature increases (Reclamation 2007).

Water quality conditions in UKL are mostly attributed to nutrient loading (Buchanan et al. 2011). The lake was highly productive or “eutrophic” prior to settlement by Europeans in the mid-19th century, but it has become “hypereutrophic” from loading attributed to external (i.e., pumping of diked wetlands, agricultural runoff, timber harvest, and road development) and internal sources (i.e., lake sediments) (Snyder and Morace 1997, ODEQ 2002, IMST 2003, Bradbury et al. 2004, Eilers et al. 2004, NRC 2004). Phosphorus is the primary nutrient responsible for this hypereutrophic condition in combination with large blooms of the nitrogen-fixing algae, AFA. Phosphorus is borne by and stored in sediments (ODEQ 2002, Graham et al. 2005). Sediment accumulation rates dramatically increased during the 20th century, and these “modern” sediments are higher in nitrogen and phosphorus than during pre-settlement (Eilers et al. 2001).

Dissolved phosphorous concentrations have repeatedly been implicated in favoring the growth of algae in the lake (Buchanan et al. 2011). Geologically controlled background inputs of dissolved inorganic phosphorous are high enough to have supported frequent algal blooms, but at lower concentrations than those observed in the past half-century (NRC 2004). Current average concentrations entering the lake are two-thirds higher than background (Buchanan et al. 2011). In the lake, concentrations of phosphorous peak in mid-summer at about six times background level (NRC 2004), probably as a result of phosphorous recruitment from pore waters of sediments on the lake bed. High concentrations of algae and intermittent stratification of the warm lake waters eventually cause algal death and depletion of DO (NRC 2004).

Wetlands may affect water quality through production and release of decomposition products, particularly dissolved humic[20] substances that appear to inhibit AFA growth (Geiger et al. 2005). The absence or reduction of this algae species within marsh environments has been noted at Hanks Marsh (Forbes et al. 1998) and Upper Klamath NWR (Sartoris and Sisneros 1993 cited by Campbell 1993). Perdue et al. (1981) noted the absence of AFA in UKL at a location heavily influenced by the Williamson River, which transports water originating from the Klamath Marsh. Although the exact mechanisms are not well understood, the relationship between humate content from shoreline wetlands and inhibition of many planktonic algae species has been established on both a local and national level (Phinney et al. 1959, Perdue et al. 1981, Forbes et al. 1998, Geiger et al. 2005). It's likely that the physical and chemical characteristics of large lakeshore marshes around UKL historically played an important role in nutrient cycling, regulating the algal community, and other characteristics of the system (Reclamation 2007). Littoral wetlands in UKL have been drastically reduced in size due to agricultural reclamation (Reclamation 2007).

Restoration of lakeside wetlands could partially compensate for the more extensive loss of marshes, which were diked and drained for agricultural purposes, and further eliminated as a result of pumping of groundwater and lowered water tables in some areas (Buchanan et al. 2011). However, the NRC report (2004) on endangered and threatened fishes in the Basin concluded their discussion of this problem with the statement: "Current proposals for improvement of water quality in UKL, even if implemented fully, cannot be counted on to achieve the desired improvements in water quality. Thus, it would be unjustified to rely heavily on future improvements in the water quality of UKL as a means of increasing the viability of the sucker populations." However, it may not be necessary to see overall improvement in lake-wide water quality to have improvements in productivity and health of resident fish, particularly the endangered suckers because of their relatively high tolerance to poor water quality (Buchanan et al. 2011).

There has been considerable debate concerning the effect of UKL surface elevation (depth) on water quality. It has been speculated that greater lake depth mitigates low DO values, improves under-ice and winter water quality, reduces un-ionized ammonia concentrations, reduces AFA biomass by reducing light intensities, delays AFA bloom initiation in the spring, dilutes internal phosphorus loading, reduces pH, and reduces AFA biomass (USFWS 2002). However, in-depth analyses of existing UKL water quality data have not demonstrated a direct relationship between lake depth and poor water quality (Wood et al. 1996, NRC 2002, Morace 2007).

Considering that intense AFA blooms have been attributed to causing the poor water quality conditions in UKL (Bortleson and Fretwell 1993, Kann 1998, Risley and Laenen 1999, Perkins et al. 2000b, Eilers et al. 2004, Wood et al. 2006, Kuwabara et al. 2007, Morace 2007), the effect of lake level on algal biomass is of particular importance. Upon analysis of existing data, NRC (2002) found no relationship between UKL level and AFA density (represented by chlorophyll concentration) and the idea of reducing algal density by phosphorous dilution with higher lake

[20] From humus, which are dark organic material in soils, produced by the decomposition of vegetable or animal matter and essential to the fertility of the earth.

levels is "not consistent with the irregular relationship between chlorophyll and lake level." Also, NRC (2002) was unable to identify a quantifiable relationship between UKL depth and extremes of DO or pH. In fact, the most extreme pH conditions recorded for UKL during the 10-year period from 1990 to 2000 occurred in 1995 and 1996, which were intermediate water depth years, and not during 1992 and 1994 when water levels were the lowest (NRC 2002).

USGS has conducted an analysis of existing UKL water quality data from 1990 through 2006. Wood et al. (1996) and USGS, concluded that there was no evidence for a relation between any of the water quality variables considered (chlorophyll, DO, pH, and total phosphorus) and lake depth on the basis of seasonal distribution of data or a summary seasonal statistic. The analysis found that low DO, high pH, high phosphorus concentrations, and heavy blooms of AFA were observed each year regardless of lake depth. USGS repeated this analysis with a 17-year dataset (1990 through 2006) and the inclusion of 11 more years of data did not demonstrate a discernible relationship between lake depth and water quality (Morace 2007). Wood et al. (1996) did find that lower lake levels coincided with an earlier onset of the AFA bloom; however, these findings were not supported by Morace (2007) with the analysis of the more robust 17-year dataset.

Both Wood et al. (1996) and Morace (2007) found a relationship between spring temperatures and the timing of the onset of the AFA bloom. The onset of the AFA bloom was delayed when spring air temperatures were cooler (Wood et al. 1996, Morace 2007). These analyses suggest that climactic conditions may have a greater influence on UKL water quality than lake level and the other variables considered. This is not to say that depth has no effect on water quality, but that existing data and analyses have not shown a discernible relationship between UKL elevation and water quality over the range of depths that UKL has been operated at during the period from 1990 through 2006 (Reclamation 2007).

In 2002, Oregon Department of Environmental Quality (ODEQ) established a total maximum daily load (TMDL) for UKL. This TMDL targets the reduction of phosphorus as a means to reduce AFA production and improve water quality conditions. Although nitrogen is also an important nutrient for structuring algae communities and determining algal productivity, AFA is able to fix atmospheric nitrogen to meet its nitrogen needs in what may otherwise be a nitrogen-limiting environment (ODEQ 2002). Thus, phosphorus loading is particularly important in UKL in determining algal productivity and biomass, which in turn influences water quality conditions affecting native fishes (ODEQ 2002). However, there is debate as to whether external phosphorus load reduction will improve water quality conditions within UKL (NRC 2004) due to internal nutrient loading driven by the release of phosphorus from the lake bed sediments (Laenen and Le Tourneau 1996, Fisher and Wood 2004, NRC 2004, Kuwabara et al. 2007).

Ice cover conditions can occur on UKL from November through March, lasting from a few weeks in most years to several months in the coldest winters (USFWS 2008a). Although not well studied on UKL, the little information collected during ice cover events indicates that water quality parameters are not at stressful levels to suckers except for relatively low DO concentrations recorded near the lake bottom during February 2008 (Table 6-5 and Figure 6-6). Only total ammonia concentrations were measured at mid-water column through the ice at three Howard Bay sites in January 2009. It is likely that un-ionized ammonia is a very small amount of total ammonia given the relatively low water temperatures and the near neutral pH when the measurements were taken (Table 6-5). There have been no known large winter fish die-offs documented in UKL (Buettner 2007, pers. comm. cited in USFWS 2008). The Proposed Action is not anticipated to impact water quality conditions for suckers during under ice cover conditions.

Table 6-5. Water quality parameters of dissolved oxygen and ammonia concentrations were measured on two dates in 2008 and 2009 at seven locations in Upper Klamath Lake during ice cover conditions.

Date - Time	Site	Depth (meters)	Dissolved Oxygen (% saturation)	Dissolved Oxygen (mg/L)	NH3 +NH4 (mg/L)	ºC	pH
2/26/2008 11:44	AS	0.6	86.0	10.45	*		
2/26/2008 11:46	AS	1.0	85.6	10.18	*		
2/26/2008 11:51	AS	1.9	57.1	6.51	*		
2/26/2008 13:12	MN	0.6	95.2	11.96	*		
2/26/2008 13:14	MN	1.1	88.6	10.72	*		
2/26/2008 13:16	MN	2.0	48.5	5.63	*		
2/26/2008 13:19	MN	2.4	30.4	3.52	*		
2/26/2008 15:16	ML	0.5	90.2	11.30	*		
2/26/2008 15:18	ML	1.0	89.5	11.05	*		
2/26/2008 15:18	ML	1.0	89.4	11.02	*		
2/26/2008 15:19	ML	2.0	71.4	8.53	*		
2/26/2008 15:21	ML	3.1	25.7	3.00	*		
2/26/2008 15:22	ML	3.0	11.0	1.28	*		
2/26/2008 16:27	NB	0.0	83.2	10.44	*		
2/26/2008 16:29	NB	0.5	73.7	8.97	*		
2/26/2008 16:31	NB	1.1	59.9	7.14	*		
2/26/2008 16:33	NB	1.5	37.9	4.42	*		
2/26/2008 16:35	NB	1.9	13.0	1.49	*		
1/21/09 12:28	WB	0.1	101.1	11.52	*	4.15	8.44
1/21/09 12:29	WB	0.5	101.5	11.56	1.27	4.17	8.44
1/21/09 12:30	WB	1.0	101.7	11.58	*	4.17	8.45
1/21/09 13:19	HBSW	0.1	92.7	10.77	*	3.43	8.01
1/21/09 13:21	HBSW	0.5	88.4	9.91	1.72	4.76	7.78
1/21/09 13:51	HBNC	0.1	124.1	14.97	*	2.03	8.6
1/21/09 13:54	HBNC	0.5	118.3	13.64	1.39	3.70	8.56

(AS = south end of Agency Lake; MN = north end of Upper Klamath Lake midway between Ball Bay and the Williamson River mouth; ML = middle of Upper Klamath Lake midway between eagle ridge and Haglestein Park; NB = north of Bare Island; WB = middle of Howard Bay; HBSW = southwest end of Howard Bay; HBNC = southwest end of Howard Bay near Caledonia Canal).

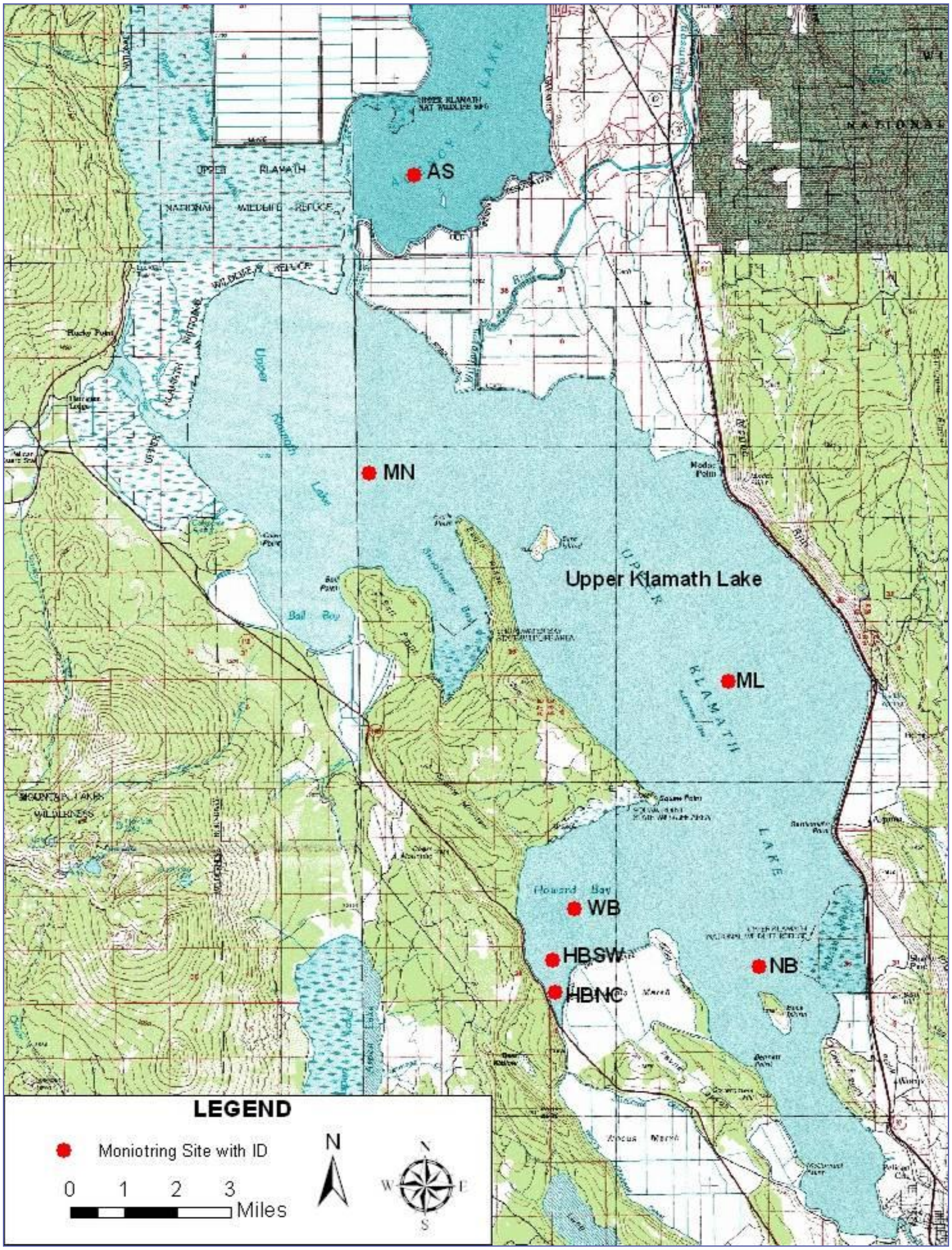

Figure 6-6. Locations on Upper Klamath Lake where water quality measurements were taken during ice cover events in 2008 and 2009. (AS = south end of Agency Lake; MN = north end of Upper Klamath Lake midway between Ball Bay and the Williamson River mouth; ML = middle of Upper Klamath Lake midway between eagle ridge and Haglestein Park; NB = north of Bare Island; WB = middle of Howard Bay; HBSW = southwest end of Howard Bay; HBNC = southwest end of Howard Bay near Caledonia Canal.)

6.2.1.3.2. Water Quality: Link to Keno Impoundment Reach of the Klamath River

Water quality conditions in the Link to Keno Impoundment Reach of the Klamath River is extremely poor, particularly during the summer, with heavy AFA growth and die-off, low DO concentrations, and high pH and water temperature (Deas and Vaughn 2006, Sullivan et al. 2008, 2011, ODEQ 2010). This area experiences seasonal poor water quality during summer months with water temperatures exceeding 25°C, pH exceeding 10, dense algae blooms dominated by AFA, and DO concentrations below four milligrams per Liter (mg/L), and often below one mg/L. Like UKL, dense blooms of AFA affect the water quality within the Link to Keno Impoundment Reach. However, the AFA blooms are typically less intense and are spatially and temporally more variable than those observed in UKL (Reclamation 2007). Persistent low DO events occur in this reach and can last for several days or even weeks where DO concentration will remain less than four mg/L, and are associated with high levels of un-ionized ammonia (Deas and Vaughn 2006, Reclamation 2007, Sullivan et al. 2008, 2011, ODEQ 2010). These degraded conditions can occur throughout much of the 20 mile-long reach.

The quality of water entering, within, and leaving the Link to Keno Impoundment Reach is largely due to poor quality water entering from UKL containing large amounts of organic matter with an associated high biochemical oxygen demand (BOD; Doyle and Lynch 2005, Deas and Vaughn 2006). Particulate organic matter (mostly AFA) that originates from UKL is overwhelmingly the largest source of nutrients relative to other nutrient sources, including agricultural, municipal, wildlife refuge, and industrial inputs (Reclamation 2007). High pH and un-ionized ammonia are also associated with the heavy transfer of AFA from UKL (Deas and Vaughn 2006). Although the water returned to the Klamath River from the Project and the Tule Lake and Lower Klamath Lake NWRs typically has higher nutrient concentrations than UKL or the Klamath River, the net nutrient load of the diverted water is reduced as it flows through the Project and the refuges (Reclamation 2007, ODEQ 2010). However, nutrient concentrations, particularly phosphorus, are higher in returned water from the LRDC and the Klamath Straits Drain than ambient River conditions and contribute to poor water quality in the Link to Keno Impoundment Reach (ODEQ 2010).

In addition to the high BOD rates of source water from UKL, the bed sediments have high sediment oxygen demand rates which further exacerbate the low DO conditions. Doyle and Lynch (2005) found that sediment oxygen demand rates in Keno Reservoir ranged from about 0.3 to 3.0 grams DO/m^2/day (median value =1.8 grams/m^2/day). The sediment oxygen demand and BOD combined can account for the severe low DO condition that develops in the reach from July into October of most years. Also, low AFA growth would result in little oxygen being produced to offset DO losses by sediment oxygen demand and BOD (USFWS 2008a).

The Klamath River in Oregon is listed as water quality impaired by Oregon under Section 303(d) of the Clean Water Act, requiring the development of TMDL limits and implementation plans. The Oregon 2002 section 303(d) list reported that the Klamath River from UKL to the Keno Dam was impaired because pH, ammonia, DO, and chlorophyll-a do not meet applicable standards (ODEQ 2002, 2010). The basis for listing the Klamath River as impaired was aquatic habitat degradation due to excessively warm summer water temperatures and algae blooms associated with high nutrient loads, water impoundment, and agricultural water diversions.

6.2.1.3.3. Water Quality: Clear Lake Reservoir

At Clear Lake Reservoir, lower water levels may result in degraded water quality, particularly higher water temperatures and lower DO. However, water quality monitoring over a wide range of lake levels and years documented water temperatures and DO concentrations that are periodically stressful to suckers but were generally adequate for sucker survival (Reclamation 1994a, 2000, 2001, 2007). During 2005 when surface elevations were between 4,524.76 and 4,521.79 feet from June 1 through September 30, Clear Lake water temperatures peaked in mid-July and remained above 20ºC from July through August in the east lobe (Figure 6-7, Reclamation 2007). DO concentration demonstrated a similar seasonal trend as water temperature with concentrations above 5.0 mg/L in both lobes throughout the summer except for the east lobe on one date in mid-August. There are few large scale impacts outside of cattle grazing and road infrastructure in the Clear Lake Reservoir drainage that likely influence water quality.

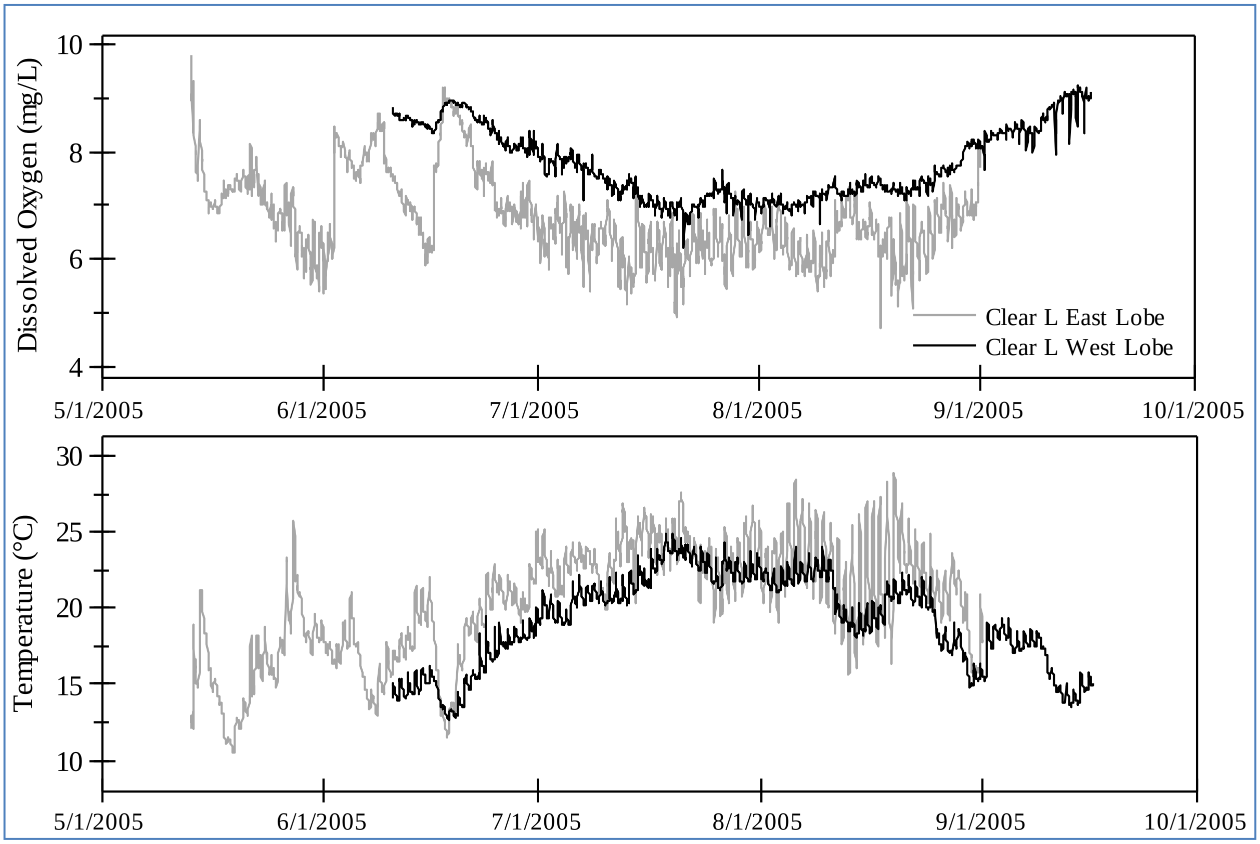

Figure 6-7. Water temperature and dissolved oxygen concentrations in the west and east lobes of Clear Lake Reservoir between mid-May and mid-September, 2005 (Reclamation 2007).

6.2.1.3.4. Water Quality: Gerber Reservoir

About 75 percent of the land in the Gerber Reservoir watershed is publicly owned under the jurisdiction of the U.S. Forest Service, Fremont National Forest, and the U.S. Bureau of Land Management, Klamath Resource Area. The condition of the watershed upstream of Gerber Reservoir is relatively good (USFWS 2008a). Both U.S. Forest Service, Fremont National Forest, and the U.S. Bureau of Land Management, Klamath Resource Area have consulted with the Service under section 7 of the ESA on grazing management in the watershed and implemented management actions that protect sucker habitat (USFWS 2002, 2008).

Water quality monitoring over a wide range of lake levels and years has documented water quality conditions that are periodically stressful to suckers but were generally adequate for sucker survival (Reclamation 2001a, 2007, Piaskowski and Buettner 2003, Phillips and Ross 2012 draft). Generally, water quality is better in Gerber Reservoir than in other large reservoirs in the Upper Klamath Basin (Phillips and Ross 2012 draft). Observed water quality conditions in Gerber Reservoir (i.e., temperature, pH, and DO) were adequate for suckers except low DO concentrations during portions of some winter months during ice cover conditions and portions of all summer months (Piaskowski and Buettner 2003). During summer and early fall, weak stratification of the water column develops occasionally in Gerber Reservoir particularly at sites near the outlet where depth is greatest (Piaskowski and Buettner 2003). When the Reservoir is stratified, DO concentrations of less than four mg/L were observed at depths generally greater than four meters. This stratified condition, and associated hypoxia, typically persists for less than a month and over a small portion of the Reservoir near the dam (Piaskowski and Buettner 2003). Winter stratification and the brief periods during summer months when DO concentration is low create stressful conditions for suckers. There have not been any observed fish die-offs reported from Gerber Reservoir.

6.2.1.3.5. Water Quality: Tule Lake

Tule Lake is classified as highly eutrophic because of high nutrient concentrations and resultant elevated aquatic plant productivity (USFWS 2002, ODEQ 2010). Tule Lake water quality is affected by its various sources of inflow:

1. Primarily UKL surface water during irrigation season through the LRDC and A Canal.

2. Local runoff during winter and spring months from lands below Wilson Reservoir on the Lost River.

Also contributing to the eutrophic status of Tule Lake is its shallow bathymetry and internal nutrient cycling from lake sediment. Water quality can vary seasonally and diurnally, especially in summer. Water quality in the sumps is very similar to UKL with large fluxes in DO and pH (Buettner 2000, Hicks et al. 2000, Beckstrand et al. 2001). Due to the lake's shallowness and high biomass of aquatic macrophytes and filamentous green algae during summer, DO and pH levels fluctuate.

Water quality conditions in Tule Lake during the winter are relatively good, except during prolonged periods of ice cover when DO concentrations decline (USFWS 2008a). A small adult sucker die-off occurred during the winter of 1992-1993 during an extended period of ice cover and low DO concentrations (Reclamation, unpublished data, cited in USFWS 2008). A minimum elevation of 4,034.0 feet from October 1 to March 31 was set to provide adequate winter depths for cover and to reduce the likelihood of fish die-offs owing to low DO concentrations below ice cover (USFWS 1992, 2008a).

6.2.1.3.6. Water Quality: Lost River

Natural eutrophic conditions were likely to have occurred in the Lost River watershed (Winchester et. al., 1995). However, the aquatic habitat conditions were greatly altered during the 20th century and current water quality conditions are often poor. The Lost River is a Clean Water Act 303(d) listed river for several impairments in Oregon and California. The U.S. Environmental Protection Agency (EPA), by consent decree, has established TMDLs for nitrogen and BOD to address DO and pH impairments for the California portion of the Lost River (Reclamation 2009).

Numerous reaches of the Lost River experience seasonally low DO concentrations that likely stress suckers (i.e., values less than four mg/L; EPA 2007). Extremely low DO concentrations have been measured in Wilson Reservoir, Harpold Reservoir, and at Anderson Rose Dam in the Lost River (Reclamation 2009). Periodic fish die-offs occurred in the Lost River during the 1990s and 2000s (Reclamation 2009). Whereas DO concentrations can periodically reach stressful conditions throughout the Lost River, median DO concentrations indicate that the middle reach of the Lost River may be the most water quality impaired (Figure 6-8). Eight stations registered DO concentrations of 1 mg/L or less, which is likely to be acutely lethal for suckers (Saiki et al. 1999). Dissolved oxygen lethal concentration (LC_{50}) in 24-hour experiments for larvae and YOY juveniles were 1.14 and 2.10 mg/L (Saiki et al. 1999).

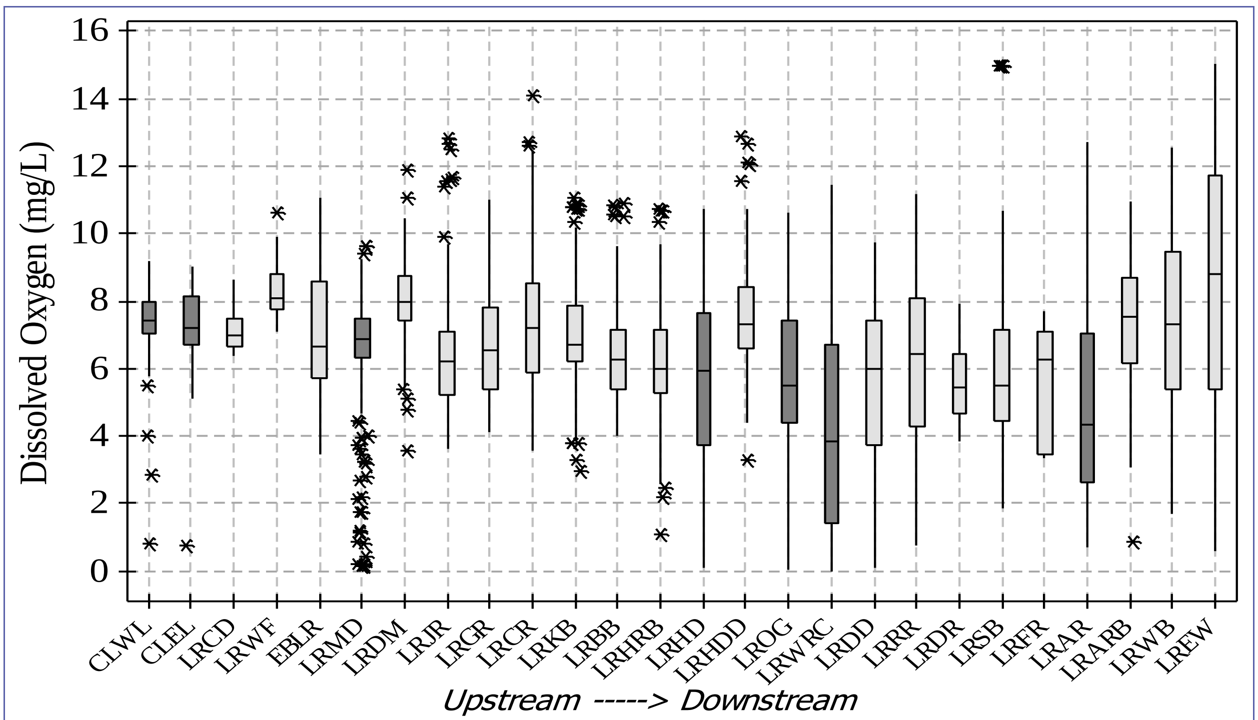

Figure 6-8. Summary of dissolved oxygen concentrations (mg/L) from 26 sites in the Lost River, 1993 to 2005, indicating slightly better dissolved oxygen at sites furthest upstream and downstream in the Lost River. Dissolved oxygen concentrations are summarized in box and whisker plots with the median, the 25th and the 75th percentiles indicated by the box. Asterisks represent outlier observations (Reclamation 2007).

Water quality degradation in the Lost River system is being addressed by a TMDL target, which is regulated by the states with oversight from EPA under section 303 of the Clean Water Act (Table 6-6; EPA 2008, ODEQ 2010).

Table 6-6. Total maximum daily load sources and impairments for upper Klamath River and Lost River Basins from the State of Oregon (from ODEQ 2010).

Parameter	Geographic Area	Season	Responsibility (Land Uses, Sector)	Quantity
Dissolved Oxygen	Lost River drainage, Lost River Diversion Channel (LRDC), and Klamath Straits Drain	Year Round	Agriculture Forestry	% Nitrogen, phosphorus, and BOD5[a] reduction and DO[b] allocation
	Keno Reservoir	Year Round	Agriculture, Forestry, Hydromodification, Urban Transportation, Sewage Treatment	% Phosphorus, nitrogen, and BOD5 reduction, temperature and DO allocation
pH	JC Boyle Reservoir	Year Round	Hydropower	DO[b], temperature allocation
	Lost River drainage LRDC, and Klamath Straits Drain[c]	Year Round	Agriculture Forestry	% Nitrogen, phosphorus, and BOD5 reduction, and DO allocation
	Keno and JC Boyle Reservoirs	Year Round	Agriculture, Forestry, Hydropower, Urban Transportation, Sewage Treatment	% Nitrogen, phosphorus, and BOD5 reduction, and DO allocation
Ammonia Toxicity	Lost River drainage LRDC, and Klamath Straits Drain[a]	Year Round	Agriculture Forestry	% Nitrogen, phosphorus, and BOD5 reduction and DO allocation
	Keno Reservoir	Year Round	Agriculture, Hydromodification, Urban Transportation, Sewage Treatment	% Phosphorus, nitrogen, and BOD5 reduction and DO allocation
Chlorophyll-a	Lost River drainage, LRDC, and Klamath Straits Drain[a]	Year Round	Agriculture Forestry Urban Transportation	% Nitrogen, phosphorus, and BOD5a reduction and DO allocation
Temperature	Link River to state line	June 1 to September 30	Agriculture, Forestry, Hydropower, Urban Transportation, Sewage Treatment	Natural thermal potential
	Streams in the Upper Klamath and Lost River Subbasins	Year Round	Agriculture Forestry	% effective shade

[a] 5-day test for biochemical oxygen demand.
[b] Dissolved oxygen.
[c] Load allocations for Keno Reservoir.

For the Lost River, the following prescriptive reductions are required:

1. At least 50 percent reduction of dissolved inorganic nitrogen.

2. At least 50 percent reduction of carbonaceous BOD.

3. DO augmentation at Wilson Reservoir, Anderson-Rose Reservoir, and Klamath Straits Drain.

4. Temperature maintenance to meet combined allocated ΔT 0.075°C to Klamath River for Klamath Straits Drain and LRDC discharges (ODEQ 2010).

Plans to meet these requirements are currently in development.

6.2.1.4. Pesticide and Herbicide Applications

Approximately 80% of Project lands, including private and public, are managed for agricultural production where pesticide use is common. A majority of Project irrigation drainage is received in the area that drains into the Tule Lake sumps within TLNWR. Thus if pesticide residues were to occur in drain water from these lands, it would be most apparent in Tule Lake. Surveys regarding pesticide and herbicide impacts to suckers have largely focused on the Tule Lake sumps as a likely place that agrochemicals may accumulate within the Project.

Pesticide/herbicide concentrations may also accumulate on drain waters and discharge into the Lost River and the Link to Keno Impoundment Reach through the Klamath Straits Drain or the LRDC. Therefore, the risk from chemical exposure for suckers in the Lost River and the Link to Keno Impoundment Reach is likely similar to the risk for suckers in the Tule Lake sumps. The risk to the suckers posed by pesticide use is dependent on many factors, including chemical toxicity, mobility, persistence, amount applied, application method, and proximity of application area relative to nearby water bodies.

Once in the sumps, they volatilize, degrade, settle to the bottom with sediment, or remain in the water column where they would be highly diluted (USFWS 2008a). Based on ecological fate analyses for pesticides used on the federal lease lands (USFWS 1995), it is anticipated that pesticide use does not likely pose a threat to Lost River and shortnose suckers in Tule Lake when label directions are followed and when appropriate buffers are in place (USFWS 2008a), and are consistent with the 1995, 1996, and 2008 BOs on pesticide use.

There is little doubt that at least trace amounts of pesticides reach the Tule Lake sumps. Since the late 1980s, low levels of pesticides were detected in the sumps (Sorenson and Schwarzbach 1991, Dileanis et al. 1996, Asbill-Case et al. 2012 draft). Of the pesticides detected in waters and sediments around Tule Lake, the levels are below those known to be acutely toxic to aquatic life (Dileanis et al. 1996, Eagles-Smith and Johnson 2012), except for detections of bifenthrin and prodiamine during two sample dates in 2011 (Asbill-Case et al. 2012 draft). A nation-wide assessment by USGS from 1992 to 2001 found pesticides at low concentrations were nearly ubiquitous in the Nation’s streams and rivers, even in undeveloped watersheds (Gilliom et al. 2006).

Between 1998 and 2000, several wildlife mortalities and fish kills were documented and investigated on Tule Lake NWR, but with the exception of one incident in which off-refuge use of acrolein caused a fish kill, there was little supporting evidence that implicated pesticides as causative agents in any of the mortality events (Snyder-Conn and Hawkes 2004). However, the results of the study did reveal some evidence of trace wildlife exposure to the herbicides dicamba and 2,4-D and a few cases of limited acetylcholinesterase inhibition in birds, suggesting potential low-level exposure to organophosphate or carbamate insecticides (Snyder-Conn and Hawkes 2004, Eagles-Smith and Johnson 2012). However, some pesticides and herbicides in use within the Klamath Basin can be toxic at very low concentrations (Eagles-Smith and Johnson 2012).

Monitoring efforts in 2011 indicated that bifenthrin may be reaching Tule Lake in concentrations that adversely affect fish and prodiamine may be reaching Tule Lake but at concentrations not anticipated to adversely affect fish (Asbill-Case et al. 2012 draft). These chemical compounds are likely reaching Tule Lake from chemical applications on private lands (Asbill-Case et al. 2012 draft). Recent pesticide/herbicide sampling at Tule Lake Sump 1A in 2011, detected two pesticide compounds (bifenthrin and prodiamine), out of an analysis for approximately 190 compounds, during two of the 14 sampling events (Asbill-Case et al. 2012 draft). Positive detections of both bifenthrin and prodiamine were identified on April 13, 2011 in Tule Lake Sump 1A near the middle of the sump, and bifenthrin was again identified on April 27, 2011, in the Lost River just upstream of Tule Lake Sump 1A (Asbill-Case et al. 2012 draft). The bifenthrin detection was 9.0 micrograms per Liter (µg/L) on April 13, 2011, and was 1.9 µg/L April 27, 2011 (Asbill-Case et al. 2012 draft). These concentrations are above the acute and chronic Aquatic Life Benchmarks for fish which are developed to register products (USEPA 2011). No Observed Effect Concentrations and Lowest Observed Effect Concentrations for bifenthrin were developed by California Fish and Game (2000) on fathead minnows at 0.56 and 1.09 µg/L, respectively. The Australian Government (2010) developed No Observed Effect Concentrations and Lowest Observed Effect Concentrations at 12 µg/L for rainbow trout (*Oncorhynchus mykiss*).

Using data modeling and "weight-of evidence" approaches have shed qualitative light on the likelihood of impacts to threatened and endangered species in the Klamath Basin (Eagles-Smith and Johnson 2012). Specifically, in 2007 the USFWS modeled the risk of multiple pesticides to listed suckers in Tule Lake by incorporating estimates of application rates and subsequent drift or runoff into surface waters and exposure scenarios based on known water usage patterns (Haas 2007). When combined with toxicity estimates from test organisms and data on the compounds' environmental fates, it was determined that Vapam (a soil fumigant) and Lorsban (an organophosphate insecticide) posed the greatest risk to listed suckers, but that they were not likely to pose substantial risk to either species (Haas 2007). This determination was based on the estimated pesticide surface-water concentrations in the Tule Lake sumps being below toxicity thresholds for other fish species (Eagles-Smith and Johnson 2012).

Based on limited existing data on pesticide impacts and distribution, pesticide use information, benchmark toxicity values, and habitat use of the threatened and endangered species, a 2007 BO (USFWS 2007d) evaluated impacts from direct exposure to the organisms, indirect effects through pesticide-induced reduction in prey populations, and pesticide-induced reductions in water quality. Although the assessment found that some level of pesticide exposure could occur to listed species, the evidence did not support a determination that the pesticide applications were likely to cause harm to the species considered (USFWS 2008a).

While most of the sampling to date in Tule Lake suggests pesticides may not be present in concentrations that would adversely affect suckers, a lack of detection of toxic pesticides does not necessarily mean they would not have adverse effects on Lost River or shortnose suckers (USFWS 2008a, Eagles-Smith and Johnson 2012). Highly toxic pesticides, like metam-sodium (Vapam), can harm fish at low concentrations, indicating that some chemicals may be present at low but harmful concentrations and may escape detection during surveys. Further, many of the newer pesticides are difficult to monitor due to their rapid break down (USFWS 2008a). Although Asbill-Case et al. (2012 draft) indicates bimonthly water samples taken during the Vapam application period resulted in no detections at Tule Lake Sump 1A. Reclamation (2012) conducted an ecological risk assessment specific to soil fumigants (e.g.,Vapam) used on federal lease lands within TLNWR analyzing the toxicity, environmental fate, transport, and exposure pathways. The assessment indicated there is “sufficient information that ecological risks to terrestrial, aquatic, and invertebrate species are negligible” for the majority of exposure scenarios.

In a review of existing pesticide data from the Upper Klamath Basin, Eagles-Smith and Johnson (2012) indicate that monitoring efforts to date have not been sufficient to detect low concentrations, or trace amounts, of pesticides that could have harmful impacts. In addition to possible adverse impacts from chemicals at concentrations below acute effects low concentrations or below detectable levels (Eagles-Smith and Johnson 2012), bifenthrin and prodiamine have recently been detected in Tule Lake and the bifenthrin detection was at a concentration that could adversely impact aquatic life (Asbill-Case et al. 2012 draft, Syngenta 2008, Australian Government 2010). Although the pesticide compounds bifenthrin and prodiamine were detected, these pesticide compounds currently are not approved for use on federal lease lands. This suggests that the origins of these compounds are coming from pesticide applications on lands not under Reclamation or USFWS jurisdiction. Current pesticide use on federal lease lands is consistent with and covered under the *Formal Section 7 Consultation for the Implementation of Pesticide Use Program on Federal Leased Lands, Tule Lake and Lower Klamath National Wildlife Refuge, May 31, 2007,* and pesticide use on Project facilities and rights-of-way is consistent with and covered under the 1995 and 1996 BOs.

6.2.1.5. Fish Health - Disease, Pathogens, Parasites, and Toxins

Degraded water quality conditions may weaken fish and increase their susceptibility to disease and parasites (Holt 1997, Perkins et al. 2000b, ISRP 2005). New information indicates that pathogens substantially affect sucker survival, especially during adverse water quality events. Although fish die-offs that occurred in UKL in the 1990s were likely a response to hypoxia (low levels of DO), disease outbreaks also probably contributed to mortality during these events as indicated by suckers continuing to die after water quality improved (Perkins et al. 2000b, NRC 2004).

A number of pathogens have been identified from moribund (dying) suckers, but *Columnaris* disease or “gill rot” seems to be the primary organism involved (Foott 1997, 2004, Holt 1997). It is caused by the bacterium *Flavobacterium columnare,* which can damage gills, produce body lesions, which leads to respiratory problems, an imbalance of internal salt concentrations, and provides an entry route for lethal systemic pathogens (ISRP 2005). A total of 304 bacterial genera were detected in skin mucous of YOY juvenile suckers from UKL, several of which are potentially pathogenic (Burdick et al. 2009). Further research is necessary to determine which bacteria pose a serious health risk to suckers (Burdick and Hewitt 2012).

Parasites were not identified as a threat at the time of listing, but recent information indicates they could be a threat to the suckers (Buchanan et al. 2011). Parasites can lead to direct mortality, provide a route for pathogens to enter fish through wounds, and can make fish more susceptible to predation (Robinson et al. 1998).

Lernaea sp., a parasitic copepod or “anchor worm,” which feeds on fish tissues by puncturing the skin of its host (Briggs 1971), is a common parasite on suckers in the Upper Klamath Basin. *Lernaea* infestation was apparently absent prior to 1995. Low-level *Lernaea* infestation was first seen on YOY Lost River and shortnose suckers in 1995 but prevalence (percent infested) increased substantially in the mid-to late-1990s and peaked for both species in about 2003 and 2004 (Simon et al. 2012).

Prevalence of Digenea, a sub-class of parasitic trematode flatworms which causes “black spot,” on age-0 suckers was variable from 1991 to 2011, ranging from 20 to 65 percent on YOY shortnose suckers, and 3 to 21 percent on YOY Lost River suckers. Digenea prevalence on shortnose suckers was relatively constant from 1991 through 2009 but has sharply increased since 2010 to a high of 65 percent in 2011. Digenea prevalence was relatively low on Lost River suckers from 1991 through 2011, but showed the same rapid increase in 2010 and 2011 as in shortnose suckers (Simon et al. 2012).

The effect of Digenea presence on sucker growth was strongly negative for shortnose suckers but positive for Lost River suckers (Simon et al. 2012). Larger juvenile Lost River suckers had Digenea present than smaller individuals and smaller juvenile shortnose suckers had Digenea present than larger individuals. For shortnose suckers, but not for Lost River suckers, there was also a “dose effect” where growth became more negative with higher numbers of Digenea infections (Simon et al 2012). Both parasite infections of *Lernaea* and Digenea should be viewed as providing a biological tag with potential implications that there appear to be differences in host specificity and that there appears to be significant mortality associated with these parasites (Simon et al. 2012). However, the severity and specific mechanism by which *Lernaea* and Digenea may reduce sucker survivorship has not been identified, and some fish species are relatively tolerant of the presence of these parasites.

Some cyanobacteria such as *Microcystis aeruginosa* which is present in UKL (VanderKooi et al. 2010, Eldridge et al. 2012) produce biotoxins that may result in fish mortality. Recent studies by USGS provide preliminary support for a hypothesis that juvenile suckers in UKL are exposed to biotoxins at concentrations that are much higher than those considered safe for drinking water and nearly 50 percent of juveniles collected in UKL during 2007 had liver damage consistent with exposure to microcystin (VanderKooi et al. 2010). Nitrogen fixation by *AFA* early in the sample season appears to provide new nitrogen for growth of toxigenic *Microcystis aeruginosa* (Eldridge et al. 2012). Later in the season, the two species appear to co-exist. The cycles of the two species suggest microcystins in UKL may be regulated by phosphorus availability (Eldridge et al. 2012). Additional work is needed on the subject of microcystins and endangered suckers to understand if fish consume microcystins in concentrations high enough to promote tissue damage and mortality (Eldridge et al. 2012). It is hypothesized that the route of exposure to microcystin is through biomagnification, in which suckers consumed chironomids that had eaten the toxic algae (VanderKooi et al. 2010).

6.2.1.6. Entrainment Losses

Entrainment of listed suckers can occur from the downstream movement of fish into diversions or spillways by drift, dispersion, and volitional migration (PacifiCorp 2012). Effects to fish associated with entrainment may include harassment, injury, and mortality as fish pass through or over spillways, into canals, or into pumps. Spillway mortality of entrained fish can occur from strikes or impacts with solid objects (e.g., baffles, rocks, or walls in the plunge zone), rapid pressure changes, abrasion with the rough side of the spillway, and the shearing effects of turbulent water (Clay 1995). Entrainment at and lack of passage through Klamath River dams and other irrigation structures were added to the list of threats to the endangered suckers after the original listing (USFWS 1992, NRC 2004). Entrainment into irrigation and power-diversion channels is now recognized as being responsible for losses of "millions of larvae, tens of thousands of juveniles, and hundreds to thousands of adult suckers each year" (NRC 2004). Alterations at the southern end of UKL, such as channel cuts in natural reefs, and alterations in Lake hydrology likely contribute to entrainment of suckers from UKL (USFWS 2008a).

Entrainment also occurs at other diversion dams in the Project including the following: Clear Lake, Gerber, Miller Creek, Malone, Wilson and Anderson-Rose (Reclamation 2002). Clear Lake Dam was screened in 2003 excluding entrainment of juvenile and adult suckers but not larvae. The effectiveness of the screen in excluding juvenile and adult suckers was verified in 2003 when fish salvage operations conducted below Clear Lake Dam at the end of the irrigation season captured only three suckers (Bennetts et al. 2004) compared to several hundred suckers captured before the screen was installed (Piaskowski 2002). Numerous additional point diversions exist in the Project area including: A Canal (UKL); J Canal, Q Canal, Pumping Plant D and R Canal (Tule Lake sump); and the Lost River Diversion Canal and its associated lateral canals (Reclamation 1992, 2001). See Reclamation (2001b) for more comprehensive list of diversion locations and estimated diversion quantities within the Klamath Project.

Much of the effort to estimate and understand entrainment of suckers has focused on fish that move downstream from UKL. Although entrainment has not been measured at all diversions, entrainment of suckers likely occurs at other locations within the Project, particularly at unscreened diversions or diversions nearest to known populations of suckers.

Reclamation completed construction of a fish screen at the entrance to the A Canal in March 2003 to reduce fish entrainment known to occur at this diversion (Reclamation 2007). UKL has been suggested as a better suited environment for suckers than the Link to Keno Impoundment Reach of the Klamath River due to the food rich environment in UKL and the frequency and duration of poor water quality events in the Klamath River (Reithal 2006, Markle et al. 2009), and access to spawning (USFWS 2008a). The Lost River sucker and shortnose sucker were particularly vulnerable to entrainment at A Canal before the screen was installed. Entrainment studies at the south end of UKL from 1997 to 1999 (Gutermuth et al. 2000a, 2000b) have been utilized to estimate and understand entrainment from UKL at the Link River, A Canal, and both the East Side and West Side power developments at the Link River (USFWS 2007c, 2008, 2009, Tyler 2012a, 2012b).

Entrainment of young fish is a potentially important contributor to recruitment failure, given that the entrained larvae and YOY juveniles likely originate from known spawning aggregations in the tributaries or shoreline areas, and individuals exiting UKL to the south are permanently lost from the population (NRC 2004). Recruitment of adults has been sporadic in Lost River sucker populations of UKL making it difficult to identify substantial population growth through consecutive years from the available data (Janney and Shively 2007, Janney et al. 2007, Hewitt et al. 2011). Shortnose suckers have not demonstrated measurable recruitment from 1997 through 2004, and show a net population decline over this period (Janney and Shively 2007, Janney et al. 2007, Hewitt et al. 2011).

Entrainment estimates from UKL are typically based on extrapolation of observations from Gutermuth et al. (2000a, 2000b) with A Canal fish screen assumptions and annual updates for inter-annual sucker production and water conveyance (USFWS 2008a, Tyler 2012a, 2012b). Annual estimates for suckers exiting UKL via the Link River are variable and range between 100,000 and 6,000,000 for larvae, between about 10,000 and 140,000 for juveniles, and usually fewer than 230 adult suckers (USFWS 2008a, Korson et al. 2011, Korson and Kyger 2012, Tyler 2012a, 2012b). Not all sucker entrainment at the southern end of UKL is lethal (PacifiCorp 2012), and the Link River Dam fish ladder allows the return to UKL for some individuals, principally older juvenile and adult sucker life history stages, that were carried downstream of the dam (Kyger and Wilkens 2011a, 2012 draft). Furthermore, there is some recent evidence that sucker dispersal in UKL has changed with the reconnection of wetland habitat near the Williamson River (Simon et al. 2011, 2012, Wood et al. 2012) and is influenced by environmental conditions (Wood 2012, Wood et al. 2012).

Of the number of YOY juvenile suckers entrained each year from UKL, some individuals may survive in the Link to Keno Impoundment Reach of the Klamath River (Reithal 2006, Terwilliger et al. 2004, Phillips et al. 2011, Tyler and Kyger 2012). While this reach does not provide ideal conditions, some of these suckers may survive to older juvenile and adult life history stages and attempt returns to UKL via the Link River Dam fish ladder. However, the number of individuals that do survive in the Link to Keno Impoundment Reach is likely small. Of an estimated 6 million larvae, 100,000 juveniles, and 100 older juvenile/adult suckers that disperse annually into the Link to Keno Impoundment Reach from UKL, an estimated 80 percent of these fish perish (i.e., about 5 million larvae, 80,000 juveniles, and 80 older juvenile/adult suckers annually) due to the impaired water quality conditions below the Link River (USFWS 2007c).

Population impacts due to the loss of larval, juvenile, and adult suckers are uncertain (USFWS 2008a, PacifiCorp 2012). Numbers of larval suckers that are estimated to be lost through entrainment represent a small proportion of the potential fecundity of the breeding population. Each female shortnose and Lost River sucker can produce up to 72,000 and 236,000 eggs per year, respectively (Perkins et al. 2000a). There are thousands of reproductively active female suckers in UKL each year (Janney et al. 2008, 2009, Hewitt et al. 2011), suggesting a high reproductive potential in any given year when conditions encourage it.

Whereas, there are no reliable estimates for larval and YOY juvenile suckers (USFWS 2007a, 2007b), there are extrapolations of data from surveys that inform us on the magnitude of early life history stage entrainment from UKL. Data from the Klamath Tribes (1996) estimated the total annual production for larval suckers at about 73 million. The entrainment of an estimated 6 million larval suckers represents approximately seven percent of the total annual sucker production at that life history stage (USFWS 2007c). More recently, Simon et al. (2012) estimated the number of larval suckers in UKL between 19 and 29 million based on an extrapolation of early June fish surveys in 2011. Estimated entrainment at the southern end of UKL was 2.4 million larval suckers in 2011 based on amount of water exiting UKL and the magnitude of larval sucker production (Tyler 2012b). These numbers suggest that larval entrainment could represent 8 to 13 percent of estimated numbers of larval suckers available in UKL during a given year. Although using a combination of work by Simon et al. (2012) and Tyler (2012b) represents a higher percent of total annual production than using earlier estimates of larval production, data suggests that sucker larvae in 2011 were mostly retained in UKL by the central gyre rather than by shoreline retention (Simon et al. 2012). How the number of larval suckers produced and entrained affects recruitment to the adult populations in UKL is still uncertain (PacifiCorp 2012).

Entrainment of YOY juvenile suckers is also variable between years and can represent a substantial percent of the annual sucker production. Low cast net catches of YOY suckers in Lake Ewauna and higher catches in northern and middle UKL in 2011 suggest that retention of juvenile suckers was relatively high in 2011 with about 850,000 YOY juvenile suckers of both species present in early August of that year (Simon et al. 2012). Estimated entrainment at the southern end of UKL was about 7,000 YOY juvenile suckers (Tyler 2012b); however, monitoring at the fish bypass at A Canal estimated that about 140,000 YOY juvenile suckers were bypassed back to UKL (Korson and Kyger 2012). An entrainment estimate of 7,000 juvenile suckers represents less than 1 percent of 2011 YOY juvenile sucker abundance (i.e., 850,000), but using 140,000 bypassed YOY juveniles as an entrainment number represents greater than 16 percent of the 2011 YOY juvenile sucker abundance.

The magnitude of impacts to UKL sucker populations from entrainment losses is not understood. Sucker entrainment from UKL is associated with high estimated mortality to relatively large numbers of individual suckers (PacifiCorp 2012). It is not yet known if mortality associated with entrainment is additive to natural mortality for suckers in UKL. Eby and Corsi (2009) assumed that entrainment of cutthroat trout into irrigation canals added six percent to the natural mortality among Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) of the lower Gros Ventre River of Wyoming. They concluded entrainment could impact populations of trout in the lower River based on the assumption that entrainment mortality was additive (Eby and Corsi 2009). Carlson and Rahel (2007) suggested fish entrainment evaluations need to take a Basin-wide population perspective, and cautiously concluded that entrainment mortality was relatively small in relationship to natural mortality for Bonneville cutthroat trout (*Oncorhynchus clarkii utah*) and brown trout (*Salmo trutta*) in Smiths Fork, Wyoming. Each study was able to calculate or assume natural mortality for the study species in order to evaluate the fish entrainment.

Currently, information is available to estimate that natural mortality for adult suckers in UKL is relatively low (Hewitt et al. 2011) and mortality for larval suckers is relatively high (Cooperman et al. 2010). However, information is currently lacking to calculate mortality during the YOY juvenile sucker life history stage or the mortality between the YOY juvenile and adult sucker life history stages. Based on the lack of recruitment among adult suckers in UKL (Hewitt et al. 2011), the mortality at the juvenile or the juvenile-to-adult life history stage is high. An assumed high, natural mortality makes it difficult to evaluate impacts from entrainment to sucker populations in UKL.

The number of suckers entrained at facilities decreases progressively downstream from the Link River Dam (PacifiCorp 2012). This corresponds to the relative distribution of the suckers in reservoirs downstream of the Link River Dam (PacifiCorp 2012). Each of these reservoirs, including the Link to Keno Impoundment Reach of the Klamath River, is likely seeded by larval and juvenile suckers emigrating from UKL (Desjardins and Markle 2000). Based on entrainment studies at Link River Dam and fish distribution studies in reservoirs, substantial numbers of larval and juvenile suckers disperse downstream from UKL to reside in the downstream reservoirs (USFWS 2007c). There is no evidence that self-sustaining populations exist in any of the reservoirs, but it is possible that some larval and juvenile suckers in the Link to Keno Impoundment Reach are from spawning in the Link River (Smith and Tinniswood 2007). However, it is more likely that most of the suckers in the Link to Keno Impoundment Reach arrived from UKL (Markle et al. 2009). Shortnose sucker spawning and larval production occurs in Copco No. 1 Reservoir; however, there is little recruitment into the adult population (USFWS 2007c).

Annual entrainment losses from the Link to Keno Impoundment Reach via the spillway at Keno Dam are nearly 570,000 larvae, nearly 15,000 juveniles, and 15 adult suckers (PacifiCorp 2012). Of these entrainment estimates, approximately 12,000 larvae and nearly 300 juveniles are thought to expire as a result of trauma while passing the spillway at Keno Dam (PacifiCorp 2012).

Entrainment losses from the Link to Keno Impoundment Reach are also likely through the LRDC and other unscreened diversions (North Canal, Ady Canal, and other diversions). Sampling in the LRDC between Reeder Road and Tingley Lane captured eight juvenile suckers in 64 trap nets fished on 16 sample dates (Foster and Bennetts 2005). Sampling was conducted weekly from late May through late September and represents 1200+ hours (Foster and Bennetts 2005). During the same effort, a screw trap was fished on seven dates between mid-July and early September at Station 48 on the LRDC capturing two suckers (one juvenile and one dead adult; Foster and Bennetts 2005). Fish entrainment monitoring at Miller Hill Pumping Station which feeds parts of C Canal from the LRDC in July and August 2008 did not capture suckers but did capture other fish species (Korson 2010). Fish sampling near Ady and North canals indicated the juvenile suckers are present near both locations during the summer (Phillips et al. 2011). These efforts indicate the presence of suckers in relatively low abundance in the LRDC and near other diversions that are susceptible to entrainment.

Miller Creek is located at the outlet of Gerber Reservoir and extends about nine miles downstream until it enters the upper Lost River (Reclamation 2001a). Water is released at Gerber Dam into Miller Creek for irrigation during April through September. About midway between the Dam and the Creek's confluence with the Lost River, flows are diverted into North Canal during the irrigation season. After irrigation season, remaining flows in upper Miller Creek come from groundwater influences and a small amount of flow from valves on Gerber Dam left open to prevent winter freezing of the gate controls. However, during wet years when Gerber Reservoir spills, winter and spring flows in Miller Creek can reach several hundred cfs. Shortnose suckers, presumably from the Lost River near Bonanza, spawn in the lower reaches of Miller Creek during April and May of some years (Reclamation 2001a, USFWS 2002). During a spill event in 1999, adult shortnose suckers were observed spawning in Miller Creek (USFWS 2008a). Spawning runs are infrequent during non-spill years and passage from the Lost River may be restricted by the shallow water depths at the mouth of Miller Creek (Reclamation 2001a, ISRP 2005). Gerber Dam is not screened against the entrainment of fish from the Reservoir. The infrequency of spawning in Miller Creek and the absence of a fish screen at Gerber Dam suggests that most of suckers encountered in Miller Creek are likely a result of entrainment from Gerber Reservoir.

Past survey efforts of Miller Creek indicate that up to several hundred suckers are likely entrained into Miller Creek from Gerber Reservoir annually. In 1992 and 1993, 229 and 34 shortnose suckers, respectively, were salvaged immediately below Gerber Dam (Reclamation 1994b). Most fish in both years were juveniles (Reclamation 1994b). Since 1993, no salvage has occurred below Gerber Dam due to safety considerations (Bennetts and Piaskowski 2004). In 2003, Reclamation captured 72 juvenile suckers (YOY and older juveniles) in Miller Creek below Gerber Dam during 1,078.9 hours of screw trap sampling from June 12 through October 1 (Hamilton et al. 2004). Sucker catch per unit effort is approximately 0.067 suckers per hour. Assuming a static catch per unit effort for suckers, the estimated number of individuals that would have been captured in screw trap sampling of Miller Creek throughout the 2003 irrigation season is approximately 217 juvenile suckers (e.g., 135 days*24 hours*0.067 suckers per hour).

Reclamation also operated a screw trap in North Canal (of Miller Creek drainage) in 2003 and captured 49 juvenile suckers during 1,193.9 hours of screw trap sampling from June 4 through October 1 (Hamilton et al. 2004). The sucker catch per unit effort is approximately 0.041 suckers per hour, and indicates an estimated 133 juvenile suckers were entrained into North Canal during 2003 (e.g., 135 days*24 hours*0.041 suckers per hour).

Based on fish salvage and screw trapping data from Miller Creek, up to 250 suckers are annually entrained from Gerber Reservoir. Some entrained suckers may survive in pools of Miller Creek between annual irrigation seasons; however, most of these fish likely die as a result of dewatering Miller Creek at the end of the irrigation season.

Unquantified sucker entrainment also occurs at Clear Lake Reservoir, at locations within the Lost River, Tule Lake, and at other unscreened diversions throughout Project (Reclamation 2001b).

6.2.1.7. Bird Predation

Bird predation on suckers has recently been identified through the recovery of PIT tags at fish-eating bird colonies at UKL and Clear Lake Reservoir. Surveys for PIT tags and observations during 2010 at a tern nesting island in Sheepy Lake indicate that Caspian tern (*Hydroprogne caspia*) rarely fed on juvenile suckers (Roby et al. 2011). Preliminary results from similar survey efforts in 2009 and 2010 at bird nesting areas in UKL and Clear Lake Reservoir indicate that American white pelican, double-crested cormorant, herons, and gulls collectively feed on suckers in the Basin (Roby et al 2011). Due to the close proximity of bird nests at UKL and Clear Lake Reservoir, researchers were unable to attribute fish predation by bird species (Roby et al. 2011). Based on the higher number of PIT-tagged adult suckers in the Upper Klamath Basin than any other sucker life history, much of the inference regarding predation based on tag recoveries is related to adult suckers (Roby et al. 2011).

Preliminary estimates of minimum annual consumption rates based PIT tag recoveries at Clear Lake in 2008, 2009, and 2010, indicate that bird predation is similar between Lost River and shortnose suckers and ranged between zero to 1.6 percent, per year, of available PIT-tagged suckers in the Upper Klamath Basin (Roby et al. 2011). Recovered PIT tags from Clear Lake Reservoir included tags that were implanted in suckers that were released at other locations, principally UKL demonstrating that piscivorous water birds nesting on islands in Clear Lake Reservoir traveled to other Lakes and streams to consume PIT-tagged suckers (Roby et al. 2011). Based on PIT tag recoveries at bird areas in UKL, fish-eating birds annually consumed between zero and 3.6 percent of the available PIT-tagged suckers in the Upper Klamath Basin in 2008, 2009, and 2010 (Roby et al. 2011). The highest predation rate was associated with juvenile suckers during the spring of 2009 (Roby et al. 2011). Tag detections at American white pelican (*Pelecanus erythrorhynchos*) or double-crested cormorant (*Phalacrocorax auritus)* breeding or loafing areas in the Upper Klamath NWR on the shore of UKL and Agency Lake indicated predation caused the mortality of seven age-1+ juvenile suckers tagged in 2009 and two age-1+ juvenile suckers tagged in 2010 (Burdick 2012). Interestingly, birds nesting in Clear Lake in 2009 consumed as many PIT-tagged suckers released in UKL as birds nesting in Upper Klamath NWR on UKL during 2009 (Roby et al. 2011).

Additional information regarding factors that may influence predation on suckers by fish-eating birds is not currently understood; however, fish age, fish behavior (including that caused by disease, poor water quality and loss of deep water habitat), fish proximity to bird nesting areas, and proportion of tagged individuals relative to abundance in each body of water were suggested by the authors as possibly influencing PIT tag recovery inferences (Roby et al. 2011).

6.3. Coho Salmon

6.3.1. Factors Affecting Coho Salmon and their Habitat

The following is a discussion on select factors effecting coho salmon. Only those factors most relevant to implementing the Proposed Action are discussed.

6.3.1.1. Riverine Conditions - Hydrology

Before the construction of the Klamath Project[21] and off-Klamath Project irrigation, the general annual Klamath River hydrograph had high flows in winter and spring that declined gradually during summer and recovered in fall (NRC 2004). Following the development of the Project, when compared to the prior historical hydrograph, Klamath River flow exhibited a shift in the peak annual runoff from a mean maximum centered on April to a mean maximum centered on March (Figure 6-9, NRC 2004). The NRC (2004) speculated that the reasons for this shift toward an earlier peak in annual runoff may be associated with increased flows from the Lost River diversions into the Klamath River and the loss of seasonal hydrologic buffering that originally was associated with overflow into Lower Klamath Lake and Tule Lake. When a recent mean monthly hydrograph is compared with a historical mean monthly hydrograph, summer base flows are occurring earlier than historically (Figure 6-9).

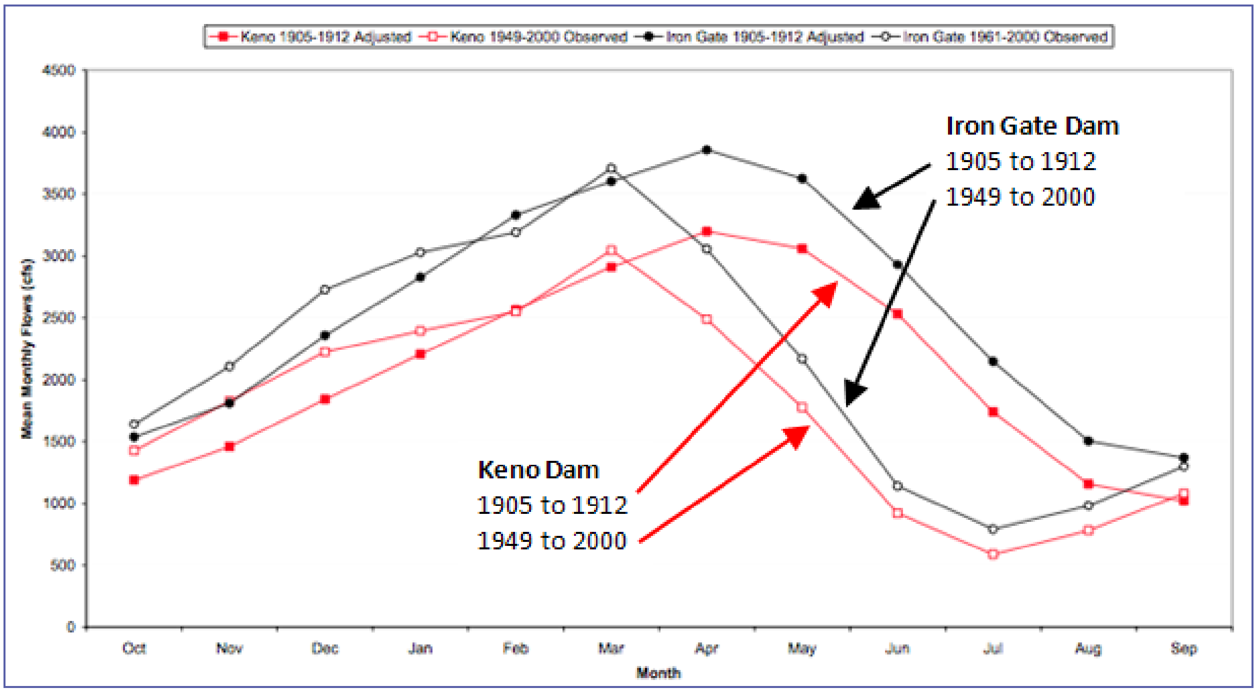

Figure 6-9. Estimated historical mean monthly flows at Keno and Iron Gate Dams compared to the mean monthly flows at Keno Dam (1949 to 2000) and immediately below Iron Gate Dam, 1961 to 2000 (Figure 4 modified from Hardy et al. 2006).

There are other factors impacting the Klamath River hydrograph besides the Project operations. For example, contributing to an early peak in the annual runoff has been widespread and regionally coherent trends toward earlier onsets of springtime snowmelt and stream flow across most of western North America primarily due to higher winter and spring temperatures (Stewart

[21] Construction began on the project in 1906 with the building of the main A Canal. Water was first made available May 22, 1907. The Clear Lake Dam was completed in 1910, the Lost River Diversion Dam and many of the distribution structures in 1912, and the Anderson-Rose Diversion Dam (formally Lower Lost River Diversion Dam) in 1921. The Malone Diversion Dam on Lost River was built in 1923 to divert water to Langell Valley.

et al. 2005). In many systems, warmer winter and spring temperatures have resulted in increasing fractions of annual flow occurring earlier in the water year by one to four weeks (Stewart et al. 2005).

The Klamath River's hydrology was further altered when the construction of IGD was completed in 1962. IGD was built to stabilize and regulate flow releases from upstream facilities operated for peaking power production. Completion of IGD did not cause substantial reduction in spring and summer flows. Iron Gate Reservoir has a relatively small active storage of only 3,790 AF. This is sufficient active storage for approximately one day of average Klamath River flows at IGD of 1,850 cfs. Thus, the completion of IGD has been a minor factor in seasonal or annual flow regimes in the Klamath River. Rather, changes in seasonal or annual flow regimes have been due primarily to ongoing land use changes, increased irrigation withdrawals, and reductions in base flows in the upper Klamath Basin over the past 50 years.

In addition, the completion of the construction of Reclamation's Trinity Dam and Lewiston Dam on the Trinity River in 1962 and 1963, respectively, has had a substantial influence on Trinity River flows and Klamath River flows below its confluence with the Trinity. Similarly, the development of Reclamation's Rogue River Basin Project from the mid-1950s to the mid-1960s further increased water withdrawals, impacting flows in the Klamath River from diversions that reduce flows in Jenny Creek, a tributary to the Klamath River upstream of IGD. Off-Klamath Project agricultural diversions in both the Shasta and Scott Rivers, especially during dry water years, can dewater sections of these rivers, further impacting the mainstem Klamath River downstream of IGD (Moyle 2002 as cited in NMFS 2012a).

A hydrograph can be separated into four components: subsistence flows, base flows, high-flow pulses, and overbank flows (Figure 6-10, NRC 2005).

Subsistence flow is the minimum flow needed during critical drought periods to maintain tolerable water-quality conditions and to provide minimal aquatic habitat space for the survival of aquatic species (NRC 2005). Hardy et al. (2006) believed that low flow conditions naturally occurred within the mainstem Klamath River downstream of the current IGD location and represents an important environmental stressor for long-term population genetics.

Base flow is the “normal” flow conditions between storms. Base flow sustains habitat that supports diverse, native aquatic communities. Base flow also maintains the groundwater level that supports riparian vegetation (NRC 2005).

High-flow pulses are short in duration and typically follow storms. High-flow pulses flush fine-sediment deposits and waste products from the system and restore normal water quality following prolonged low flows (NRC 2005).

Overbank flow is an infrequent, high-flow event that breaches riverbanks (i.e., floods). Overbank flows may restructure the channel and floodplain, recharge groundwater tables, deliver nutrients to riparian vegetation, and connect the channel with floodplain habitats that provide additional food and space for aquatic organisms (NRC 2005).

6.3.1.2. Riverine Conditions - Water Quality

Paleolimnological evidence shows that sediment and nutrient loading to the UKL and resulting biological productivity in the lake increased concurrent with increasing human settlement in the Basin (Eilers et al. 2004). However, Eilers et al. (2004) also showed that the lake was eutrophic before European settlement, presumably as a result of high levels of nutrients naturally occurring in the watershed (Dunne et al. 2011).

Much of the Klamath Basin is currently listed as water quality impaired for designated beneficial uses under section 303(d) of the Clean Water Act. As such, TMDLs have been developed by Oregon, California, and the EPA for specific impaired water bodies with the intent to protect and restore beneficial uses of water.

A recently completed TMDL analysis by ODEQ (2010) indicates that inflows from UKL via Link River account for most of the loading of nutrient and organic matter to Keno Reservoir. In Keno Reservoir, less than one percent of the loading of nutrients occurs internally (from sediments) within the Reservoir. Water quality in Keno Reservoir, which is strongly influenced by the amount of organic matter originating from UKL, exceeds the assimilative capacity of the Reservoir resulting in a considerable oxygen-demanding load on the system during the summer (Deas et al. 2006, FERC 2007a).

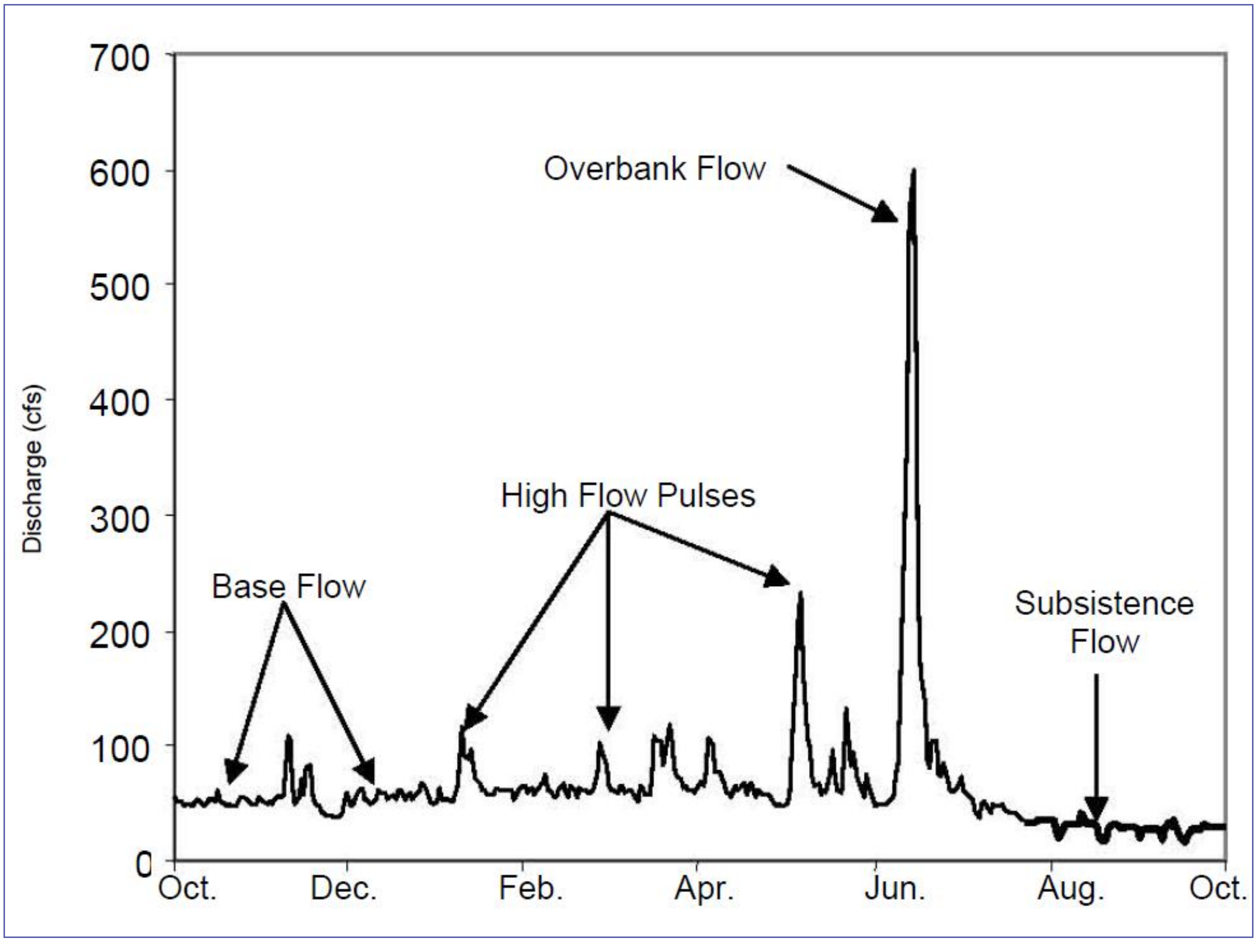

Figure 6-10. Daily stream flow hydrograph for Guadalupe River at Victoria, TX, with base flows, subsistence flows, high-flow pulses, and overbank flows identified. Data from USGS Gage No. 08176500, water-year 2000. *Source: Figure 3-1 on p. 34 of NRC 2005.*

DO Concentration: During winter, conditions are typically at or near saturation throughout the majority of the reach below IGD (PacifiCorp 2012). During late summer and fall periods when relatively deep releases from Iron Gate Reservoir entrain water with low DO concentrations result in discharges from the dam of water that is below 100 percent saturation (PacifiCorp 2012). Further, it is not uncommon to find the Klamath River at several locations farther downstream experiencing “chronic” mild sub-saturation during the warmer periods of the year (PacifiCorp 2008). These are conditions when the average DO concentration over a period of time (days or weeks) is below saturation, and DO never rises above saturation. It is postulated that this mild, persistent sub-saturation is related to the appreciable organic load being carried by the River (PacifiCorp 2012).

Periphyton and Macrophytes:[22] Photosynthesis and respiration by periphyton and macrophytes are the primary drivers of the daily cycles of DO in the Klamath River; Periphyton (algae attached to the riverbed) and macrophytes (rooted aquatic plants) have a seasonal growth pattern in the Klamath River, with low biomass during high winter and spring flows and maximum biomass reached during the low-flow warm period in mid/late summer. Factors affecting this seasonal cycle include water velocity, substrate, light, water temperature, and nutrient availability. These factors are complex and their relative contributions are not well understood in the Klamath River. High flows limit periphyton and macrophyte biomass by increasing water velocity.

The effect of periphyton and macrophytes on DO concentrations are influenced by biomass and water depth. Periphyton and macrophytes are attached to the riverbed, so when water depth is high these organisms have less effect on water column DO concentrations because their oxygen production (photosynthesis) and consumption (respiration) is “diluted” by the increased water volume. Conversely, when water depth is low, the ratio between the bed surface area and the water volume is higher, so their effect on DO is greater.

pH Level: pH tends to vary seasonally, rise throughout the summer, peaking in late August (NMFS 2007a). Given that the Klamath River downstream of IGD remains in a weakly buffered state, pH levels throughout the river can experience wide diel fluctuations as a result of high primary production (i.e., algae and benthic macrophyte growth) during summer months. Photosynthesis and associated uptake of carbon dioxide by aquatic plants result in high pH (i.e., basic) conditions during the day, whereas plant and fish respiration at night decreases pH to more neutral conditions (NMFS 2010). Ammonia toxicity can also be a concern in aquatic environments, like the Klamath River, where high nutrient concentrations coincide with elevated pH and water temperature.

Temperature: Water released from IGD has both direct and indirect effects on downstream water temperature in the mainstem Klamath River. The magnitude of these effects depends on three principal factors: the temperature of the water as it is released from the dam, the volume of the release, and the meteorological conditions (e.g., ambient air temperature). These factors, along with what the impacts of IGD releases may have on the minimum, mean, and maximum daily temperatures are discussed below.

Temperature of the Water: Iron Gate Reservoir releases are generally moderated owing to the reservoir volume and a penstock release elevation that is about 30 feet deep. These attributes lead to water temperatures that may be at or slightly below equilibrium temperature of the river downstream of IGD in the spring (PacifiCorp 2012). Currently, the temperature of water released from IGD peaks at about 22ºC (+/–2ºC) occurring in August (NRC 2004). In addition, the mass of water in the PacifiCorp’s Reservoirs causes a “thermal lag” compared to the same

[22] The following information on periphyton and macrophytes was provided by Michael Belchik, Yuork Tribe in an email dated October 08, 2012 to Kristen Hiatt. The email and supporting documents provided preliminary results showing there is a relatively strong relationship between flow and both daily minimum dissolved oxygen concentrations and the daily range of dissolved oxygen concentrations.

location in the Klamath River under a hypothetical “without-dam” or river-only scenario (NMFS 2012b). The natural seasonal trends of warming river temperatures in the spring and cooling temperatures in the fall are expected to be “lagged” about two to four weeks with the existence of the reservoirs (NMFS 2012b). Water temperatures downstream of IGD (RM 190.5) are generally at or near equilibrium with ambient air temperature, with the exception of immediately downstream of IGD and in the vicinity of certain tributaries (PacifiCorp 2012).

IGD release is the predominate factor for the water temperature between IGD and the Shasta River. The Shasta River is the first major tributary of the mainstem below IGD. Tributary and spring contributions to the Klamath River downstream of IGD also influence mainstem temperatures, particularly at low flows. For example, IGD releases typically contribute less than 20 percent of the flow at Orleans (RM 57.6) in May and June. The other 80 percent of the flow is derived primarily from tributaries (1962 to 1991, Hydrosphere Data Products, Inc. 1993). Thus, at low IGD releases, temperatures in the mainstem Klamath River are affected substantially by the Scott River and minimally by the Shasta River (NRC 2004).

Meteorological Conditions: During summer months, water released from IGD may already be at a temperature that is considered a stressor to juvenile coho salmon. Like the majority of the river, the channel immediately downstream of IGD is simple in form and wide enough to be essentially un-shaded (Dunne et al. 2011). The intense solar warming can increase temperatures even higher, up to 26°C, as flows travel downstream (NRC 2004). Primarily because of the influence of ambient air temperatures, the warmest reach of the Klamath River under existing conditions is the reach between approximately Seiad Valley (RM 129), and Clear Creek (RM 98.8; Appendix 8A-8).

Bartholow (2005) also found a high probability that water temperature has been increasing by approximately 0.58°C/decade (95 percent confidence interval 0.42 to 0.608°C/decade) since the early 1960s. He also found little indication that water temperature trends on the Klamath River were related to any systematic change in mainstem hydrology downstream of IGD. Instead, water temperature trends were supported by the estimates of Basin-wide air temperature warming (Bartholow 2005). Campbell (2001) also found that air temperature was generally highly correlated with water temperature with r values ranging from 0.8 to 0.9 during a water quality study in the mainstem Klamath River from 1996 through 1998.

Minimum, Mean, and Maximum Daily Temperatures: Diurnal cycles are changes over a 24-hour period that are in addition to seasonal temperature changes. For example, solar radiation during the day may warm river water temperatures followed by cooling at night. Figure 6-11 provides the daily maximum and minimum water temperate for USGS gauge 11523000 Klamath River at Orleans for a 10 day period in July, 2003.

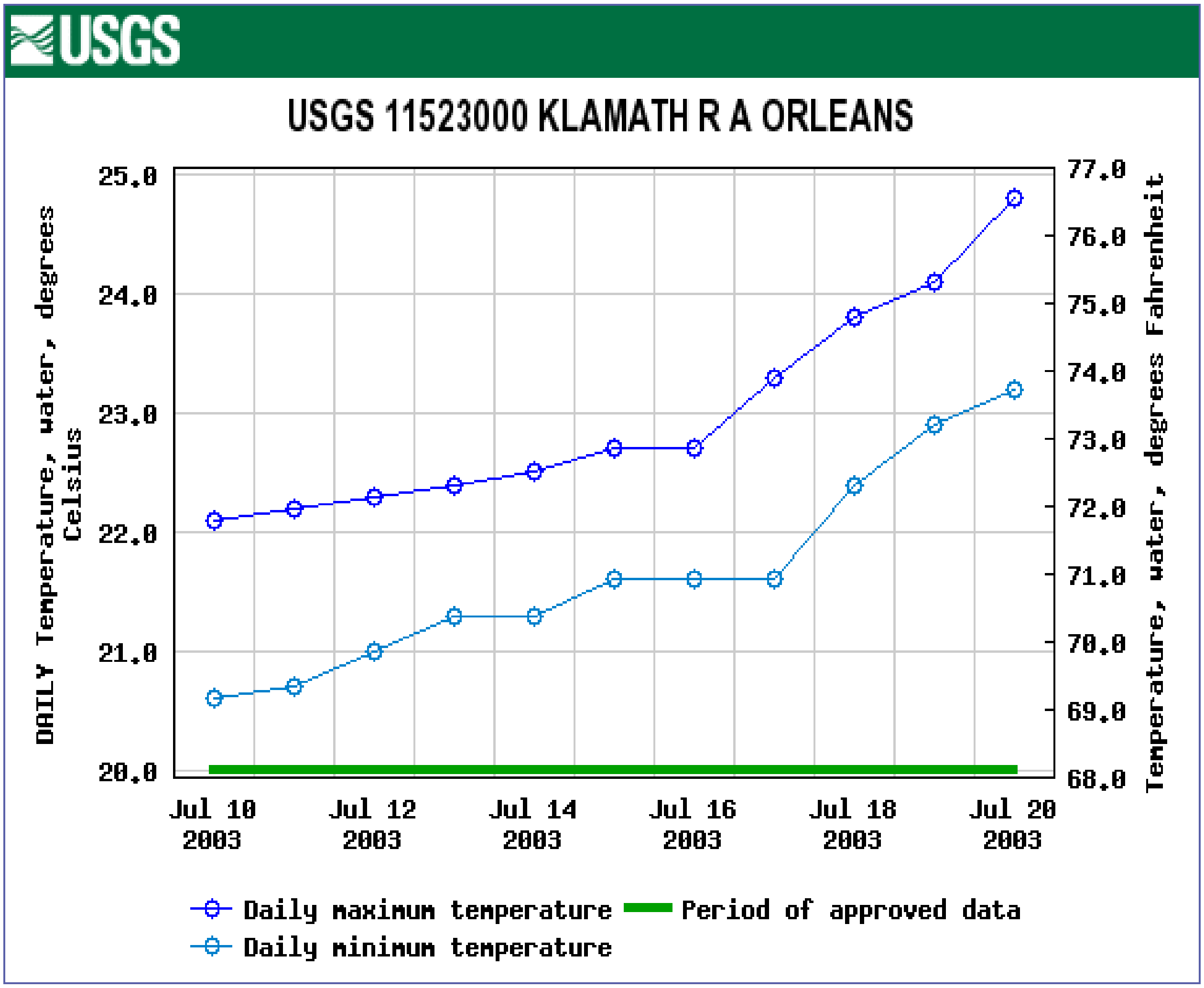

Figure 6-11. Daily maximum and minimum water temperature for USGS gauge 11523000 Klamath River at Orleans for a 10 day period in July, 2003. Water temperature information is available for this gauge from October 10, 1965 to November 30, 2003.

During the summer, NRC (2004) found that the potential benefit from increased IGD releases during the summer is confounded by relationships between minimum, mean, and maximum temperatures. Low flows have longer transit times and are susceptible to greater exposure to environmental conditions than high flows. Thus, low flows show greater change in temperature per unit distance. For example, a 500-cfs IGD release is estimated to take 2.5 days to reach Seiad Valley (RM 129), a distance of about 60 RMs; whereas a 1,000 cfs release is estimated to move the same distance in two days and a 3,000-cfs release does so in 1.25 days (Deas 2000).

Simulations conducted by Deas (2000) provide insight into the thermal response of the Klamath River to increases in flow during late summer (Figure 4-4, NRC 2004). Under moderate flow conditions in mid-August (e.g., 1,000 cfs release from IGD), with typical accretions from tributaries, maximum daily temperatures increase rapidly downstream of IGD to a peak of 26ºC within 15 miles. Daily minimum temperatures caused by nocturnal cooling reach a minimum of 20ºC within about the same distance. By the time this water reaches Seiad Valley (RM 129), maximums are greater than 26ºC, and minimums are 22ºC; the average gain from IGD to Seiad Valley was 2ºC (NRC 2004).

During the summer, tripling the flow to a 3,000 cfs release[23] from IGD (Figure 6-12) provides modest reduction in mean and maximum daily temperatures, particularly in the first 20 miles of the river downstream from the dam. The increased volume of water and shorter transit time reduces the beneficial effect of nocturnal cooling in the reach between IGD (RM 197) and Seiad Valley (RM 129), and raised minimum temperatures for about two-thirds of the reach. Although increased flows reduce mean and maximum temperatures, the increase in minimum temperatures may adversely affect fish that are at their limits of thermal tolerance (NRC 2004).

6.3.1.3. Riverine Conditions - Fine Sediment and Gravel Recruitment

For all practical purposes, the amount of sediment supplied to the Klamath River from the Klamath Basin upstream of Keno Dam is negligible (Reclamation 2011). UKL, with its large surface area, traps nearly all sediment delivered from upstream tributaries, although some finer material may be transported through the lake during high runoff events.

Furthermore, the introduction of spawning gravel has decreased due to blockage by the mainstem dams. The volume and quality of spawning gravel available to adult coho salmon is especially compromised downstream of IGD where, although limited, the majority of mainstem spawning occurs (NMFS 2012a).

6.3.1.4. Climate Change

While most predicted effects of climate change cannot be forecast to occur within the 10-year time frame of this consultation, some may occur as early as the 2020s, such as increased mean seasonal runoff volume for December through March (Reclamation 2011). The Klamath River Basin is situated far enough north to support a variety of cold water fishes, and various factors position the Klamath River on an ecological "edge," with respect to water temperatures (Bartholow 2005).

If future conditions are warmer, drier or both, summer temperature conditions likely will result in a constriction of suitable rearing habitat, encroachment of warm-water predatory fishes into more of the freshwater migration habitat, and decreased coho salmon survival owing to temperature stress, increased disease, and increased competition for food and space. Climate change is postulated to have a negative impact and will likely complicate the recovery of SONCC coho salmon and make habitat conditions less favorable for survival, reproduction, and growth throughout the Pacific Northwest due to reductions in available freshwater habitat (Battin et al. 2007). The global effects of climate change on river systems and salmon are often superimposed upon the local effects within river systems of logging, water utilization, harvesting, hatchery interactions, and development (NMFS 2010). Changes in peak streamflow timing and snowpack will negatively impact salmonid populations due to habitat loss associated with lower water

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[23] Although rare, historically, Iron Gate Dam releases of greater than 3,000 cfs have occurred in June and July. In addition, historical releases have approached 3,000 cfs in September.

flows, higher stream temperatures, and increased human demand for water resources (NMFS 2010).

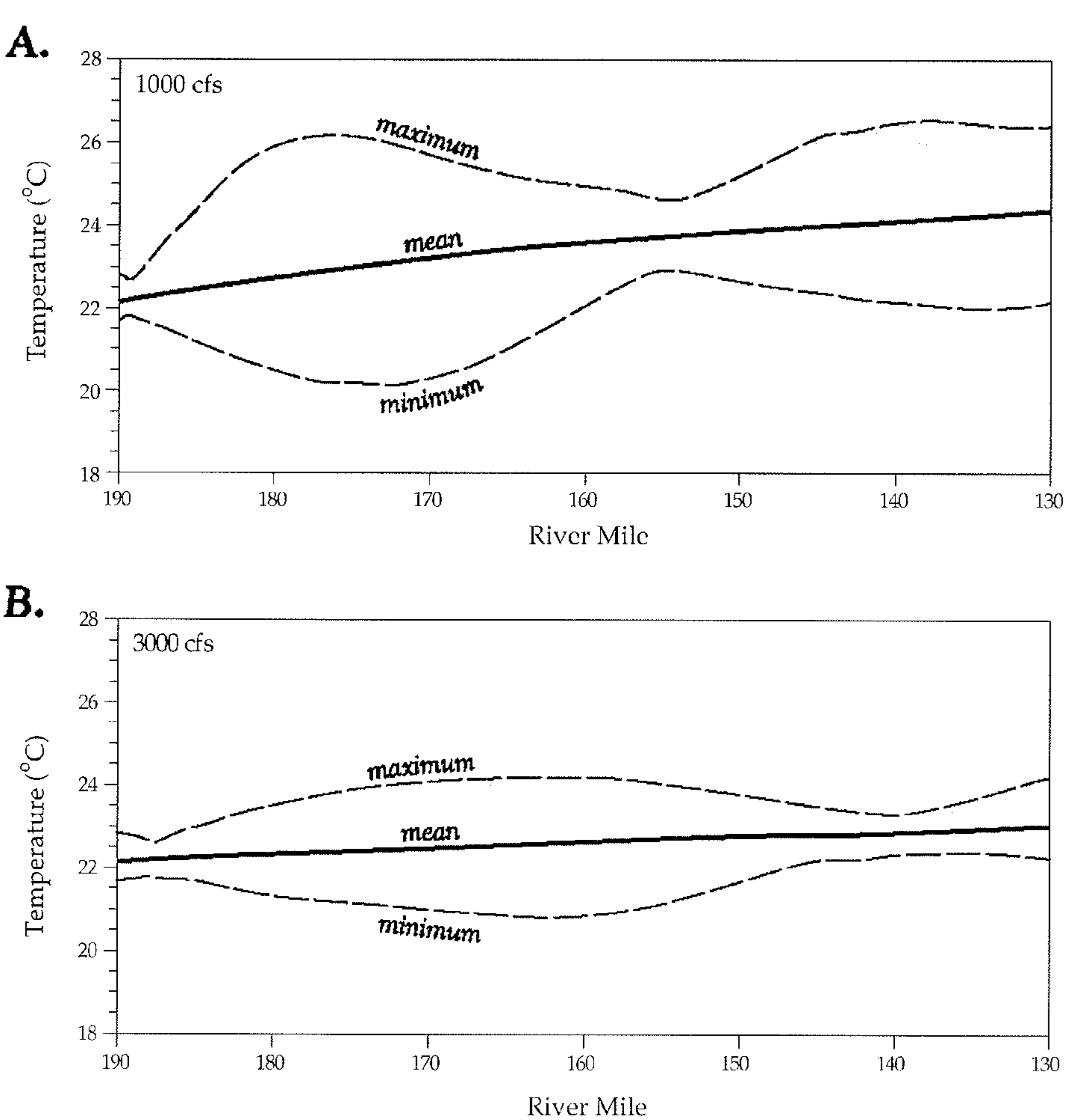

Figure 6-12. Simulated daily maximum, mean, and minimum water temperatures on the Klamath River from Iron Gate Dam to Seiad Valley for Iron Gate Dam releases of 1,000 cfs (A) and 3,000 cfs (B) under meteorological conditions of August 14, 1996. *Source: Figure 4-4B in NRC 2004; as acknowledged from Deas 2000.*

Bartholow (2005) suggests that the increasing average water temperature trend in the Klamath River mainstem of 0.58°C/decade for the 40-year post-dam period, 1962 through 2001 - a change with potentially significant ramifications for the aquatic community - were supported by the estimates of Basin-wide air temperature warming. Bartholow (2005) found little indication that the increasing average water temperature trend in the Klamath River mainstem was related to any systematic change in mainstem hydrology below IGD (although changes at a monthly scale may deserve additional attention). Bartholow (2005) concluded that if warming does continue, recovery of naturally-reared anadromous salmonids in the Klamath River Basin may become increasingly problematic. This does not mean that cooler Basin tributaries could not continue to produce salmon, but natural-origin fish that rely on the mainstem as a migration corridor in times of seasonally high temperatures may not survive if they cannot adapt (Bartholow 2005). If water temperature trends of the magnitude found for the mainstem Klamath River continue in future decades, some stocks may decline to levels insufficient to ensure stock survival (Bartholow 2005).

Dunne et al. (2011) found that climate change also affects anadromous fish species by its influence on the productivity of the ocean and marine phase growth and survival of the adult fish. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare et al. 1999, Mantua and Hare 2002) related to the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El Niño condition, appear to change productivity levels over large expanses of the Pacific Ocean. Survival rates in the marine environment are strong determinants of population abundance for Pacific salmon. Poor ocean productivity can be especially detrimental to coho salmon along the Oregon and California coast, because these regions lack extensive bays, straits, and estuaries, which could buffer adverse oceanographic effects. Although climate change is predicted to produce greater upwelling in the region, the timing of upwelling may be later and less suited to the entry timing of salmon smolts into the ocean (ISAB 2007). Further reduction in survival at sea in response to climate shifts has the potential to offset potential improvements in the freshwater environment, or it could cause further reductions or even extinction of natural-origin coho salmon populations that are presently threatened with extinction (Dunne et al. 2011).

Dunne et al. (2011) concluded that natural changes in the freshwater and marine environments will play a major role in salmonid abundance, and that climate shifts will undoubtedly influence productivity and abundance of coho salmon returning to the Klamath Basin. Weitkamp et al. (1995) suggested that natural-origin coho salmon production in the SONCC ESU may not be currently sustainable.

6.3.1.5. Fish Hatcheries

Two fish hatcheries operate within the Klamath River Basin, Trinity River Hatchery near the town of Lewiston and Iron Gate Hatchery on the mainstem Klamath River near Hornbrook, California. Both hatcheries mitigate for anadromous fish habitat lost as a result of the construction of dams on the mainstem Klamath and Trinity Rivers, and production focuses on Chinook and coho salmon and steelhead.

Fish hatcheries have known impacts on naturally-produced fish. A scientific panel was convened at the request of NMFS to summarize scientific thinking on questions regarding the biological relationship between hatchery and wild Pacific salmon populations (Hey et al. 2005). The panel included scientists from a range of specialties that pertain to the questions, including population biology, evolutionary genetics, and especially salmon and fisheries biology. The panel's report titled, *Considering Life History, Behavioral and Ecological Complexity in Defining Conservation Units for Pacific Salmon* was released in June 2005 (Hey et al. 2005).

In their review of available research, the panel found that salmon reared in hatcheries differ for basic morphological and life-history traits from their wild-reared immediate relatives (Kostow 2004), and the hatchery experience has been shown to cause changes in behavior (Fleming et al. 1997, Olla et al. 1998). The panel concluded that "there are biological differences between hatchery and wild fish that arise because of the differences between artificial and natural environments" (Hey et al. 2005).

Kostow (2009) found the following factors contribute to ecological hatchery risks: large releases of hatchery fish; hatchery fish increase density-dependent mortality; hatchery fish do not out-migrate after release; and, hatchery fish have some physical advantage over natural-origin fish. These factors are discussed below.

The relative numbers of hatchery-origin fish: The relative numbers of hatchery-origin compared to natural-origin fish is an important consideration when assessing the risk of hatchery releases to natural-origin fish. Nickelson et al. (1986) demonstrated that when large numbers of hatchery coho salmon juveniles were stocked in Oregon coastal streams, the total density of coho salmon juveniles increased by 41 percent but the density of natural-origin coho salmon juveniles significantly decreased by 44 percent, suggesting that hatchery-origin fish were replacing natural-origin fish.

Predation: Another ecological mechanism that causes decreased survival is increased predation by piscivorous fish, birds, and mammals. Predators are attracted to the exceptionally high concentrations of fish that can result when hatchery fish are released. Natural-origin fish typically are intermingled among the hatchery fish, and so are also consumed at higher than natural rates when the hatchery fish are present and attracting predators (Collis et al. 1995, Nickelson 2003).

Hatchery Fish Increase Density-Dependent Mortality: Hatchery programs can significantly increase fish densities and interfere with the density-dependent mechanisms that regulate natural-origin populations. Hatchery fish can occupy habitat and consume resources that would otherwise be available to natural-origin fish. When hatchery fish are present, the dynamics of a natural-origin population can become independent of its own abundance and instead respond to much higher total fish abundance (Kostow 2009). High fish densities in fresh water have been associated with decreased growth, increased or premature emigration, increased competition for food, decreased feeding territory sizes, and increased mortalities (Gee et al. 1978, Hume and Parkinson 1987, Nielsen 1994, Keeley 2000, 2001, Bohlin et al. 2002, Zaporozhets and Zaporozhets 2004).

Hatchery Fish Do Not Out-Migrate After Release: The ecological effects of hatchery programs are most severe when natural-origin and hatchery fish share a limited environment for a substantial period of time. In particular, early life stage hatchery-origin juveniles need to use rearing habitats in fresh water before they are ready to smolt and out-migrate to the ocean

(Kostow 2009). Hatchery fish that are released as putative smolts are probably less ready to out-migrate than managers expect based on size criteria (Kostow 2009).

Besides delaying their out-migration, Kostow (2009) found that sometimes the hatchery fish never move into the ocean at all. Instead, they become residual fish, remaining to grow in fresh water until they die or return to spawning areas as resident adults. In the Pacific Northwest, residual hatchery fish are most commonly documented in steelhead (Evenson and Ewing 1992, Viola and Schuck 1995, McMichael et al. 1997) and in Chinook salmon (Gebhards 1960, Mullan et al. 1992). Residual hatchery fish probably have ecological effects similar to those of other hatchery fish: they occupy rearing habitats and compete for food and space that would otherwise be available to natural-origin fish. However, residual fish do so over a relatively longer time frame, which would increase the severity of the effects. Also, as the residual hatchery fish grow, they may become piscivorous on smaller natural-origin fish (Kostow 2009).

Hatchery Fish Have Physical Advantages Over Natural-Origin Fish: Research has demonstrated that the developmental and evolutionary forces in hatcheries and natural streams are different enough that substantial biological differences occur between hatchery and natural-origin fish (Gross 1998). The traits that have been associated with ecological risk of hatchery fish include larger sized juveniles (Berejikian et al. 1996, Rhodes and Quinn 1998, 1999, McMichael et al. 1999, Peery and Bjornn 2004) and more aggressive or dominant juveniles (Berejikian et al. 1999, Einum and Fleming 2001). These characteristics can give hatchery fish a short-term competitive edge and can increase the disruption of natural-origin fish, even if they eventually lead to poorer survival or lower reproductive success in the hatchery fish themselves (Nickelson et al. 1986, Berejikian et al. 1996, Deverill et al. 1999, Enium and Fleming 2001, Kostow et al. 2003).

The ecological effect of larger hatchery juveniles is that larger fish tend to win more competitions, placing natural-origin juveniles at a disadvantage (Kostow 2009). For example, Rhodes and Quinn (1999) studied hatchery and natural-origin coho salmon interactions following the planting of coho salmon in two Washington streams. They observed juvenile hatchery coho salmon were larger and heavier than natural-origin coho salmon at planting, but also the hatchery coho salmon had a higher growth rate in the streams and continued their size advantage through the summer growing season, implying they remained superior competitors (Rhodes and Quinn 1999).

Excessive aggressive behavior by hatchery juveniles would generally give them a competitive advantage over natural-origin fish, similar to the advantage of larger size (Kostow 2009). Large and aggressive hatchery juveniles may display more often and win more dominance challenges after they are released into natural streams. Thus, they may successfully disrupt natural-origin juveniles from their feeding territories, forcing them into marginal or more exposed habitats (Nielsen 1994, Peery and Bjornn 2004), or to undergo premature emigration (Chapman 1962). Natural-origin fish may experience poorer growth as a consequence which could impair their long term survival (Nielsen 1994, Rhodes and Quinn 1999).

Rhodes and Quinn (1998) found coho salmon reared in a hatchery dominated size-matched fish from the same parental population reared in a stream. Hatchery-reared salmon also dominated naturally spawned salmon, even when the wild salmon were prior residents. Thus the combined effects of greater size and rearing experience of hatchery-produced salmon were sufficient to overcome a wild salmon's advantage of prior residence. Fenderson et al. (1968) found that when hatchery-reared and wild landlocked Atlantic salmon (*Salmo salar*) juveniles of the same age and size were permitted to compete for social dominance and for food in aquaria, twice as many hatchery salmon attained dominance as wild salmon.

The impacts of hatchery releases may also vary by season. Although Peery and Bjornn (2004) studied Chinook salmon, their finds are likely applicable to coho salmon. Peery and Bjornn (2004) found that behavioral interactions between natural and hatchery Chinook salmon could affect aggressiveness of, and habitat use by, natural Chinook salmon. The outcome of the hatchery–wild behavioral interactions appeared related to a combination of an increase in localized fish density as occurs during supplementation stocking programs, the relative sizes of the hatchery and natural Chinook salmon, and the aggressiveness of the hatchery fish. Peery and Bjornn (2004) found these behavioral interactions between natural and hatchery Chinook salmon were different based on the season. During spring and summer the natural Chinook salmon appeared dominated by the larger and more aggressive hatchery fish. During fall, however, some natural fish exhibited aggressive and habitat-selection behaviors that would increase their energy demands and exposure to predators when similar sized hatchery fish were present (Peery and Bjornn 2004). In addition, residual hatchery-origin Chinook salmon and steelhead also likely occupy coho salmon rearing habitats. As the residual hatchery fish grow, they may become piscivorous on smaller natural-origin fish (Kostow 2009), including coho salmon.

6.3.1.6. Iron Gate Hatchery

Iron Gate Hatchery's annual goal is for a release of 6,000,000 Chinook salmon, 75,000 coho salmon, and 200,000 steelhead, annually. Prior to release, all Iron Gate Hatchery-produced coho salmon are marked with a left maxillary fin clip and released at the hatchery (California HSRG 2012). Table 6-7 lists number of Chinook salmon, coho salmon, and steelhead released for years 2001 through 2011.

Table 6-7. Iron Gate Hatchery releases, by species, 2001 through 2011.

Year	Chinook Salmon	Coho Salmon	Steelhead
2001	6,034,636	46,254	32,698
2002	6,054,571	67,933	141,662
2003	6,204,675	74,271	192,771
2004	5,790,904	109,374	148,991
2005	6,242,690	74,766	195,698
2006	7,079,930	90,652	83,099
2007	6,389,276	119,479	21,208
2008	6,436,220	54,935	18,461
2009	4,750,310	118,560	29,683

Table 6-7. Iron Gate Hatchery releases, by species, 2001 through 2011.

Year	Chinook Salmon	Coho Salmon	Steelhead
2010	5,438,684	121,560	22,500
2011	4,929,600	22,481	21,034
2001 to 2011 Average 11 Years:	**5,941,045**	**81,866**	**85,528**

Source: California Department of Fish and Game, State Wide Hatchery Database, Mark Clifford, Ph.D., Hatchery Coordinator emails dated August 21, 2011.

Hatchery and Genetic Management Plan (HGMP): California Department of Fish and Game (CDFG) (2010) and PacifiCorp have developed the HGMP for Iron Gate Hatchery operations related to coho salmon. The HGMP covers artificial production activities at Iron Gate Hatchery for the period 2010-2020. Key findings of the HGMP include the following:

1. Based on the data available, natural abundance (wild fish only) of the upper Klamath River coho salmon population unit is below the high risk abundance level (241) established by NMFS.[24]

2. Adult coho salmon natural production needs to be increased to reduce demographic and life history diversity risks to the population unit.

3. Hatchery operations need to strike a balance between genetic and demographic risk to the combined (hatchery origin and natural origin) coho salmon population.

4. Habitat quality and quantity need substantial improvement to maintain natural coho salmon production in the Basin.

Reclamation understands that the hatchery is operating under the HGMP (CDFG 2012). However, the HGMP has not yet received an ESA Section 10(a)(1)(A) permit. Thus, hatchery operations are considered part of the Baseline.

Iron Gate Hatchery Effects on Adults within the Ocean: To estimate the marine harvest of SONCC coho salmon projected exploitation rates on Rogue River and Klamath River hatchery coho salmon stocks are calculated during the preseason planning process using the coho salmon Fishery Regulation Assessment Model (FRAM, Kope 2005). Harvest options are then crafted that satisfy the 13 percent maximum ocean exploitation rate on Rogue River and Klamath River hatchery coho salmon (NMFS 2010). However, in mixed stock fisheries, the catch is composed of salmon from a variety of natural-origin and hatchery stocks and the various stocks are frequently subjected to differential harvest rates (Noakes 2000). The difference in the rate of

[24] The alternative analysis used a value of 425 for the high risk criterion. This number was adjusted to 241 by NMFS in their review of the draft HGMP to account for inaccessible habitat above Iron Gate Dam.

harvest of hatchery-origin versus natural-origin[25] Klamath River coho salmon is not known (Dunne et al. 2011), although assumed to be similar.

Dunne et al. (2011) raised the concern that directed harvest on hatchery fish potentially encourages over-harvesting of natural-origin fish when natural and hatchery fish cannot be easily identified. Hatchery salmon can sustain much higher harvest rates than natural-origin salmon simply because mortality up to the stage where the fish are released is greatly reduced in the hatchery fish. Thus, natural-origin salmon populations can be easily overharvested in mixed stock fisheries directed on hatchery-origin fish or other more abundant stocks, unless management can maintain suitable harvest rates and escapement of natural-origin salmon.

There are many examples of mixed-stock fisheries' impacts where the target stocks are hatchery fish that have artificially high productivity (Noakes et al. 2000) while the weak stocks are relatively small, less productive natural-origin populations that are intermingled among the hatchery fish and are fished at unsustainable rates (Larkin 1977). For example, Flagg et al. (1995) noted that the large releases of hatchery coho salmon on the lower Columbia River lead to harvest rates of up to 90 percent while the natural-origin populations declined to near extinction.

Levin et al. (2001) tested the hypothesis that massive numbers of hatchery-raised Chinook salmon reduce the marine survival of wild Snake River spring Chinook salmon, an ESA-listed species. Based on a unique 25-year time-series, Levin et al. (2001) demonstrated a strong, negative relationship between the survival of Chinook salmon and the number of hatchery fish released, particularly during years of poor ocean conditions. Levin et al. (2001) results suggest that hatchery programs that produce increasingly higher numbers of fish may hinder the recovery of depleted wild populations.

Using the harvest rate on hatchery-origin coho salmon as a surrogate for the harvest rate on natural-origin coho salmon in the marine mixed-stock fisheries could be concealing the actual harvest rate on natural-origin fish. Not knowing the harvest rate on natural-origin coho salmon makes it difficult to assess how the hatchery releases are contributing to the conservation and recovery of listed coho salmon in the wild.

Iron Gate Hatchery Effects during Spawning: Hatchery salmon production that leads to introgression with the natural-origin spawning salmon stocks can affect natural-origin salmon by altering their genetic composition and associated phenotypic traits that influence fitness of individuals. Araki et al. (2008) found evidence that indicates hatchery salmon have lower fitness in natural environments than natural-origin fish. Thus, hatchery strays can reduce the fitness of natural-origin fish. This decline in fitness can occur very rapidly, sometimes within one or two generations (Dunne et al. 2011). Additionally, the presence of hatchery salmon can confound interpretation of the status of natural-origin salmon (Dunne et al. 2011).

[25] "Natural-origin" fish (also known as a wild fish) is defined as: a fish descended from natural spawning in the wild.

There is evidence that Iron Gate Hatchery fish are straying to streams where they are likely to interbreed with natural-origin fish in the watershed. For example, hatchery coho salmon adult straying into the Shasta River Basin has been estimated at 2, 73, 20, and 25 percent, for the years 2007, 2008, 2009, and 2010, respectively (Chesney and Knechtle 2010); with low adult return numbers contributing to this wide variation. Ackerman and Cramer (2006) estimated that hatchery origin adult coho salmon comprise 16 percent of adult carcasses recovered in the Shasta River Basin. These data suggest that hatchery effects may be considerable for the coho salmon population within the Shasta River.

Williams et al. (2008), consider a population to be at least at moderate risk if the fraction of naturally spawning fish that are of hatchery-origin exceeds five percent. However, a panel formed during a Genetic Effects of Straying: Introduction workshop (Grant 1997) concluded that there are no "safe" levels of hatchery straying. Any level of long-term straying will change the structure of local populations. Populations are at low risk if no or negligible ecological or genetic effects resulting from current or past hatchery operations can be demonstrated. Thus, hatchery strays from Iron Gate Hatchery are placing select SONCC coho salmon populations at increased risks through reduced fitness of the natural-origin fish.

Iron Gate Hatchery Effects during the Spring Re-distribution/Rearing Period: The hatchery program's annual goal is to produce 75,000 coho salmon for release between March 15 and May 1 (California HSRG 2012), a period when natural-origin juvenile coho salmon are rearing within the mainstem Klamath River. These hatchery-origin coho salmon will be rearing in the wild prior to migrating and likely will be in competition with natural-origin salmon.

In an effort to reduce impacts of hatchery releases to natural-origin coho salmon, fish will be released at a size that mimics the size of a wild coho salmon juvenile (CDFG 2011). Some of the released hatchery coho salmon yearlings reside in the Klamath River above Big Bar for approximately 1.5 to 2 months and then migrate quickly to the ocean (CDFG 2003b). It is likely that natural-origin fish rearing in the mainstem will experience decreased growth, increased or premature emigration, increased competition for food, decreased feeding territory sizes, and increased mortalities following the release of 75,000 hatchery-origin coho salmon.

Of even more concern to coho salmon survival is the hatchery's annual release goal of 6,000,000 Chinook salmon. The NRC (2004) speculated that interactions among hatchery and natural-origin fish of all species may cause natural-origin fish, which are smaller, to move downstream prematurely when cool-water habitat becomes limiting in summer, although this possibility has not been documented for the Klamath River.

The hatchery production goal is to release 5,100,000 fall Chinook salmon smolt between May 1 and June 15 and 900,000 juveniles between October 15 and November 20, annually (California HSRG 2012). The release of 5,100,000 Chinook salmon smolt occurs during the coho salmon spring re-distribution/rearing period. These hatchery-origin Chinook salmon that may pause during their migration to the marine environment will be in direct competition with rearing natural-origin coho salmon. In addition, an unknown portion of the annual release goal of 900,000 juveniles Chinook salmon released in the fall will remain within fresh water for an extended period of time and be in competition with rearing natural-origin salmon during that period.

The goal of the hatchery program is to release 200,000 steelhead juveniles between March 15 and May 1. Broodstock for the Iron Gate Hatchery steelhead program is collected from fish that volitionally enter the fish trap located at the base of IGD and currently includes fish that demonstrate either an anadromous or resident life history (California HSRG 2012). All steelhead are released at the hatchery site and all are marked with an adipose fin clip (California HSRG 2012). The release of 200,000 hatchery steelhead juveniles will likely be in competition with natural-origin fish, including natural-origin coho salmon. In addition, the resident life history steelhead would likely prey on natural-origin rearing coho salmon juveniles and fry all year.

Hatchery Effects during the Fall Re-distribution/Rearing Period: The hatchery release of 900,000 Chinook juveniles between October 15 and November 20 (California HSRG 2012) is of concern to the fitness of natural-origin coho salmon within the mainstem of the Klamath River during the fall re-distribution/rearing period. In controlled experiments and field observations, Stein (1971) found interspecific agonistic behavior between juvenile Chinook salmon and coho salmon, including nipping, chasing, lateral display, submission, and fleeing.

6.3.1.7. Fish Disease

Salmonids in the Klamath River are exposed to a number of pathogens and diseases that can impact all life stages. Pathogens associated with diseased fish in the Klamath River include bacteria (*Flavobacterium columnare* and motile aeromonid bacteria), a digenetic trematode (presumptive *Nanophyetus salmincola*), myxozoan parasites (*Parvicapsula minibicornis* and *Ceratomyxa shasta*) and external parasites (Walker and Foott 1993, Williamson and Foott 1998).

Modifications to the Klamath River's historical hydrologic regime may have contributed to in-stream conditions that favor disease proliferation and fish infection (Stocking and Bartholomew 2007). Water temperature in the spring may also dictate proliferation of polychaete hosts, suggesting that cool, wet spring weather is important in controlling fish disease. High water temperatures can stress adult salmon and slow upstream migration rates, facilitating the transmission of bacterial pathogens such as ich and columnaris between healthy and sick fish as they crowd into the few cold water refugial areas of the Klamath River (USFWS 2003b).

2002 Fish Kill: Significant pre-spawning mortality has been observed in the Klamath River in some years (Guillen 2003). The fish kill of 2002 in the mainstem of the Klamath River was unprecedented in magnitude. On September 19, 2002, reports of dead and dying fish in the lower Klamath River were received by the Yurok Tribal Fisheries Program and other fisheries agencies. By September 27, over 34,000 fish, mostly adult Chinook salmon, were dead in the lower Klamath River (Belchik et al. 2004). Some have speculated that the blockage of upstream mainstem fish passage due to low flows contributed to a mass mortality of fish (fish die-off or fish kill) in 2002 (NRC 2004). However, a full and final explanation of mortality probably is not possible given that the fish kill was not anticipated and therefore the conditions leading to it were not well documented (NRC 2004). In addition, isolation and identification of causative factors of fish kills are, in general, complex.

The majority of the salmon estimated to have died in the fish kill were Chinook salmon. Only small numbers of coho salmon were found (estimated at 0.5 percent of total) in the 2002 fish kill. Coho salmon migration occurs later than the Chinook salmon fall migration, which probably explains why few coho salmon were affected (NRC 2004).

The CDFG has determined that infection was the direct cause of death of the fish. Both living and dead fish were infected with ich and columnaris. These two pathogens are widespread. These pathogens typically become lethal to fish when under a high degree of stress (NRC 2004).

In the 2002 fish kill, it is unclear whether low flows actually blocked upstream migration or if most of the fish stopped moving because of high temperature. The NRC (2004) speculated that it was more likely a sequence of events involving daily minimum temperature caused the mortality rather than blockage of fish passage due to low flow. Under this hypothesis, a large number of salmon moved into the River, but ceased migrating when maximum water temperatures were high enough to inhibit migration.[26]

The NRC (2004) found it likely that temperatures in the Klamath River at the site of the 2002 kill reached or approached the inhibitory migration levels. Under this hypothesis the salmon held in pools when the temperatures were high, waiting for conditions to improve before continuing upstream. Because salmon are more vulnerable to infectious diseases at higher temperatures (McCullough 1999), crowding encouraged the disease outbreak that resulted in the 2002 kill (NRC 2004).

As the season progressed, fall temperatures allowed for continued migrations. Dunne et al. (2011) found that in 2002, average daily water temperature near IGD was 20°C in early September when coho salmon began to enter the river, falling to 15°C at the beginning of the peak migration period in late October, and to less than 10°C by the end of the peak migration period in mid-November (FERC 2007 as cited in Hamilton et al. 2010). Salmon that migrated into the Klamath River after the September 2002 fish kill did not experience the high rate of pre-spawning mortality observed earlier.

Based upon comparative analysis with historical Klamath River flow records, California Department of Fish and Game (2004) could not conclusively demonstrate that water depth impeded upstream migration during the 2002 fish die-off. However, NMFS (2010) suggested that anecdotal field observations and gauge height data supported the hypothesis that some fish migration may have been impeded.

In response to the fish kill in 2002, Reclamation released approximately 590 cfs of additional water from IGD in 2002 (Appendix 8A-9), which was estimated to arrive on October 1, 2002 in the lower Klamath River (Appendix 8A-10), after the fish kill had already occurred. The NRC (2004) found this release lacked any specific justification. For relief of physical blockage, if it occurs, NRC concluded that only a large amount of water (e.g., additional release of 1,500 cfs)

[26] EPA (2003) has determined that water temperatures exceeding 21°C inhibit adult salmon migration. However, Strange (2010c) documented Chinook migrating upstream in the Klamath River at temperatures higher than 21°C.

would have been needed (NRC 2004).

Disease Effects on Adult Coho Salmon: Myxozoan parasites have complex life cycles (Figure 6-13), with an annelid typically serving as the definitive host. For both *P. minibicornis* and *C. shasta*, this host is the freshwater polychaete worm *Manayunkia speciosa* (Bartholomew et al. 1997, 2006). Thus, unlike bacterial pathogens and external parasites, transmission of myxozoan parasites is limited to areas where the invertebrate worm host is present.

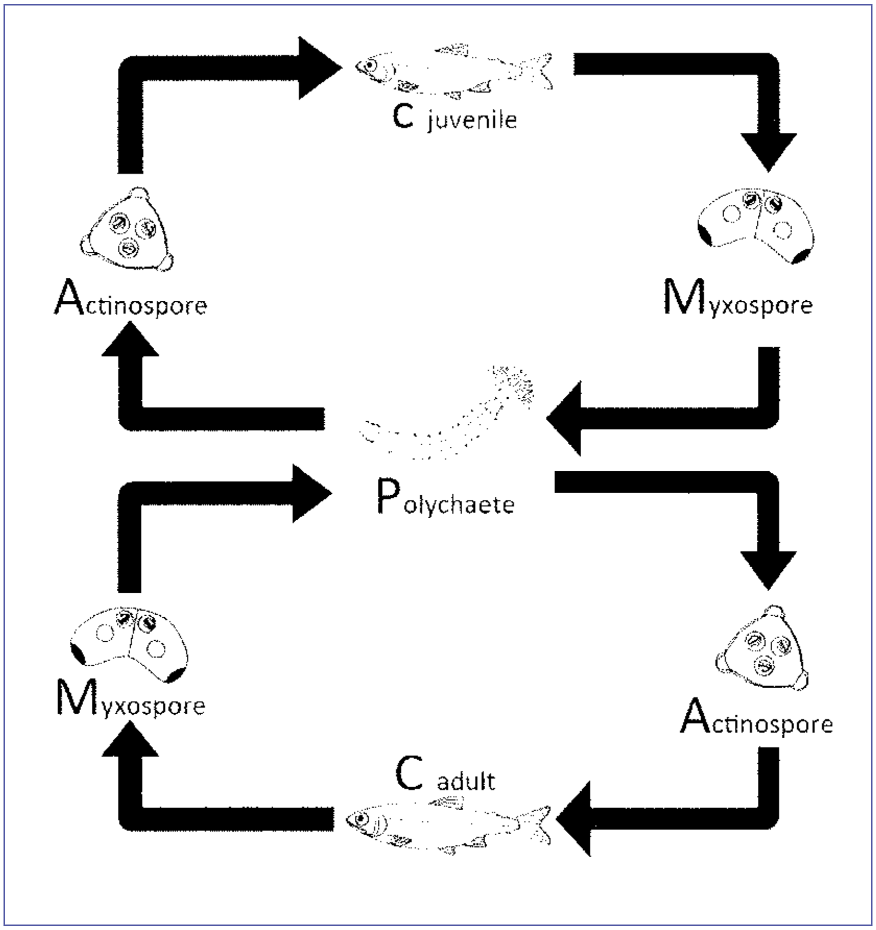

Figure 6-13. Life cycle model for *Ceratomyxa shasta* showing transmission of parasite life stages to both hosts: polychaete worms and salmon. *Source: Figure 1, Foott et al. 2011.*

To briefly describe the parasite's life cycle, *C. shasta* actinospore stages are released from infected polychaetes (Figure 6-14) into the water column as temperatures rise above 10°C in late March or early April. These actinospores are neutrally buoyant (Foott et al. 2007 as cited in Bartholomew and Foott 2010), relatively short lived (days to several weeks, Bjork 2010) and die unless encountering a susceptible fish host. Fish become infected when the parasite invades the gills (Bjork and Bartholomew 2010), traveling through the bloodstream to reach the intestine. Here, the parasite continues to replicate, causing tissue damage and eventually maturing to the myxospore stage. This stage is assumed to be released upon death of the host (i.e., released by the carcass).

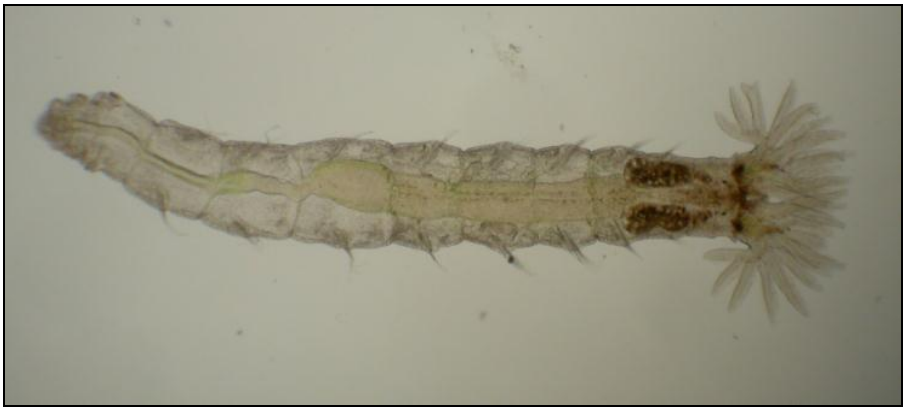

Figure 6-14. Picture of a Polychaete. *Source: PowerPoint presentation by Dr. Peggy Wilzbach at the annual Klamath River Fish Health meeting in Klamath Falls, March 2012.*

Thus, the annual infectivity cycle for polychaete populations in the Klamath River depends on salmon carcasses releasing myxospores into the water (Foot et al. 2011). A significant number of the infected carcass would be hatchery-origin fall Chinook salmon. Carcasses in the mainstem Klamath River or tributaries that are approximately up to 12 RMs upriver of polychaetes have the maximum influence on myxospore transmission (Foot et al. 2011). Approximately 45 percent of the carcasses that contribute to the current infectious zone occur in the IGD to Shasta River reach of the Klamath River. Estimated carcass numbers within this reach between 2004 and 2009 ranged from 3,587 to 5,523 Chinook salmon (Arcata USFWS annual spawner survey report as cited in Foott et al. 2011).

A pilot study examining the effect of adult carcass removal on *C. shasta* myxospore release was conducted in Bogus Creek (RM 189.6) during the fall of 2008 (Bartholomew et al. 2009). A total of 907 fall Chinook salmon carcasses were removed from the lower reach of Bogus Creek (19 percent of the total Bogus Creek run) while water samples were collected and assayed for *C. shasta*. Based on this study, Bartholomew et al. (2009) suggested that carcass removal from Bogus Creek is feasible and that water filtration can be applied for assessing success.

Disease Effects on Smolts: Modifications to the Klamath River's natural hydrologic regime, along with large loads of nutrients and organic matter in the River, may create in-stream conditions that favor disease proliferation and fish infection. These disease pathogens may impact coho salmon populations inhabiting the mainstem Klamath River downstream of IGD.

Pathogens that cause diseases in smolts include *C. shasta*, *F. columnare*, Aeromonid bacteria, *Nanophyetus salmonicola*, and *P. minibicornis* (FERC 2007b). Of these vectors, infection by the myxozoan *C. shasta* (and co-infection by a second myxozoan, *P. minibicornis*) has the most significant effect on survival of coho salmon in the subbasin (Nichols et al. 2003, Bartholomew 2008 as cited in NMFS 2012a).

Disease effects vary annually based on water temperature, water year, and other factors (Bartholomew 2008). Spatially and temporally, mortality rates from exposure to disease vary by location and time of year but are consistently higher between IGD (RM 190.5) and the Scott River (RM 143.6) and are highest April through July (Bartholomew 2008). Given that most juveniles rear in tributaries (Lestelle 2007) the greatest impacts to SONCC coho salmon through disease are due to smolts during emigration (NMFS 2012a).

Infection by *P. minibicornis* may occur at a prevalence of greater than 90 percent in Chinook salmon and over 50 percent of coho salmon migrants (Bartholomew and Foott 2010). These infections are often associated with clinical pathology, but it is unknown if they cause direct mortality. There is some experimental evidence that these fish may recover; however, the anemia associated with the infection may weaken these fish and make them more susceptible to other infections and stressors (Bartholomew and Foott 2010).

Infection by these parasites is highest in the mainstem, although Dunne et al. (2011) noted that sampling of tributaries appears to have been limited. What sampling has been done suggests little to no presence of these parasites in the tributaries. For example, in inspections of the lower and middle reaches of the Shasta River in the summer of 2009 and the spring of 2010, Strange (2010b) did not detect the presence of the polychaete worm, *M. speciosa*.

Mainstem water monitoring demonstrates that parasite abundance (i.e., actinospore stage) is low at the outflow of Iron Gate Reservoir (RM 190.5) but increases in the mainstem Klamath between the Interstate 5 (I-5) bridge (RM 179) and the confluence of the Scott River (RM 143.6). This general pattern has remained stable, but the size of the infectious zone and the magnitude of parasite densities change seasonally and annually (Bartholomew and Foott 2010). Flows in the area that encompass the infectious zone are most directly influenced by IGD and the Shasta River (Bartholomew and Foott 2010).

The reason for high parasite abundance in the mainstem Klamath River may relate to relatively eutrophic conditions there and high abundance of plankton produced in UKL and the reservoirs (Strange 2010c). Dunne et al. (2011) speculated that a reduction in loading of organic matter to the river might reduce the polychaete host densities. However, Dunne et al. (2011) also noted that the land use, hydrology, and geology surrounding UKL will likely maintain eutrophic, and even hypereutrophic, conditions in the lake.

Bartholomew and Foott (2010) reasoned that the factors for predicting where disease effects will occur include:

1. Polychaete habitat (physical habitat: pools, eddies, periphyton, sediment).
2. Microhabitats with low velocity, stable flows.
3. Close proximity to spawning areas (myxospore input).
4. Temperatures above 15°C (rate of disease development in fish).

Bartholomew and Foott (2010) speculated that there is an inverse relationship between flow rate and polychaete infection. For example, it is possible that increased flow may decrease juvenile migration time and dilute parasites, potentially resulting in decreased exposure. However, the duration of high flows necessary to disrupt high density polychaete habitat in the infectious zone and the influence of winter flows on transmission of myxospores to polychaetes is unknown

(Foott et al. 2011). Bartholomew and Foott (2010) also note that extreme low flows likely occurred naturally and, like high flows, would have a controlling effect on polychaete populations by drying habitat on vertical surfaces and stagnating pools and marginal habitats.

In field studies, the effects of flow and temperature are difficult to separate from those of infectious dose and mortality of migrating smolts (Bartholomew and Foott 2010). A sentinel[27] monitoring framework provides a tool to allow identification of the mechanism of impact. In the Klamath River, when flow and temperature during exposure are compared with mortality of sentinel Chinook salmon, no clear pattern emerges (Table 6-8 and Appendix 8A-11).

Table 6-8. Data for average temperature and flow during exposure of Chinook salmon above Beaver Creek during June 2006 to 2009. Fish were exposed for three days then held at approximately ambient river temperature following exposure.

Exposure Year	Temperature	Flow (cubic feet per second)	Percent Mortality
2004	20.6	805	48.6
2005	18.1	1,120	0
2006	19.9	3,050	16.7
2007	20.8	1,540	2.4
2008	19.1	1,960	68.4
2009	20.9	1,530	82.9

Source: Table 6.1, Bartholomew and Foott 2010.

More recently, Dr. Peggy Wilzbach, Department of Fisheries Biology, Humboldt State University, has released preliminary results on a project titled *Effect of Flow Manipulation on Polychaete Dislodgement in a Laboratory Flume.* The flume studies, measured polychaete dislodgement and survivorship under varying substrate and velocities. Dr. Wilzbach found polychaetes exhibited a variety of flow avoidance behaviors (e.g., movement to the bottom of substrates or crevices as flows are increased and orientation of their tubes with respect to flow direction). In addition, during high velocity flows the worm extruded mucus, which "repelled" the worm downstream (Figure 6-15). Some worms were able to reattach multiple times. Her results also suggested a high survivorship of any displaced worms that are dislodged due to increase flows. Dr. Peggy Wilzbach preliminary conclusions include that it is unlikely that increased flows at IGD will significantly reduce downstream polychaete populations (email from Dr. Peggy Wilzbach, Humboldt State University to A. Wilkens, Bureau of Reclamation, dated June 26, 2012).

[27] Sentinel is an individual or part of a population potentially susceptible to an infection or infestation that is being monitored for the appearance or recurrence of the causative pathogen or parasite.

Incidence of disease is highest within the reach between the Shasta River (RM 177.3) and the Scott River (RM 143.6) with decreasing incidences downstream (NMFS 2012b). However, this region appears to be growing in a downstream direction. Disease effects are most pronounced for juveniles that are rearing or migrating in the mainstem Klamath River when water quality conditions make them more susceptible to disease and when actinospore concentrations are high (NMFS 2012b). Infection rate of juvenile coho salmon is difficult to predict (NMFS 2010). The likelihood that an individual juvenile coho salmon downstream of IGD may contract disease is a function of a number of variables, including flow (NMFS 2010).

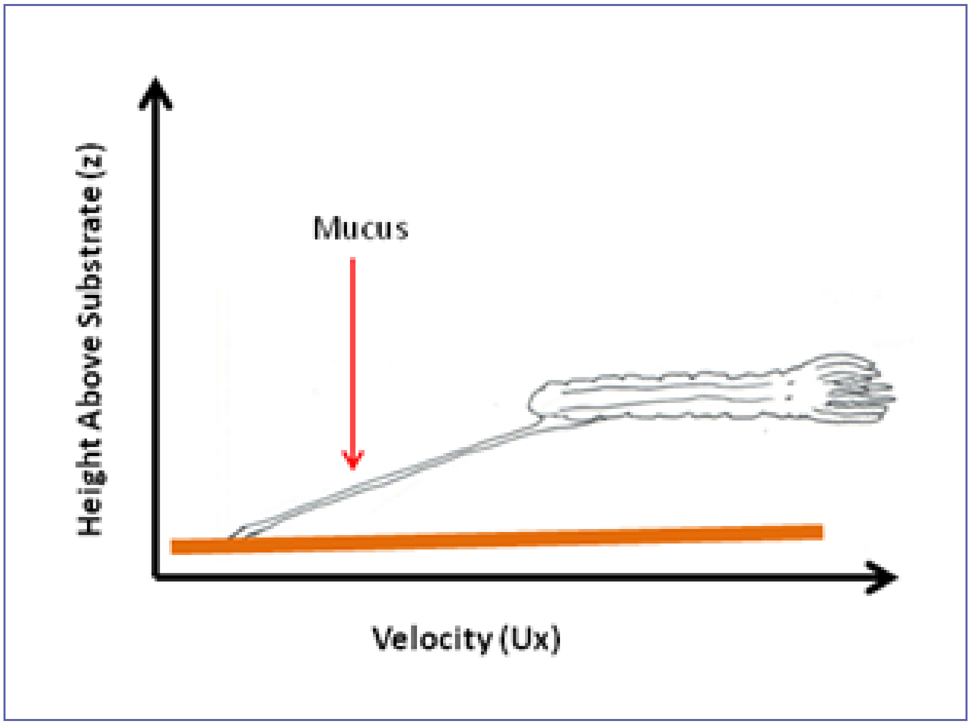

Figure 6-15. Extrusion of mucus that "repelled" the worm downstream during high flow velocity events. *Source: PowerPoint presentation by Dr. Peggy Wilzbach at the annual Klamath River Fish Health meeting in Klamath Falls, March 2012.*

Although disease may be impacting salmon survival, Beeman et al. (2012) found in four years of study from 2006 to 2009 that the survival of juvenile coho salmon migrating seaward in the Klamath River downstream from IGD was similar or greater than survival of juvenile salmonids in several other regulated river systems. The reach-specific estimates of survival ranged from 0.877 to 0.992 and were lowest in the Shasta River to Scott River reach and highest in the Salmon River to Trinity River reach (Beeman et al. 2012). Results from this study indicate discharge at IGD has a positive effect on apparent survival of yearling coho salmon in the Klamath River upstream from the Shasta River, but the effects are smaller than those of water temperature and are mediated by it (Beeman et al. 2012).

6.3.1.8. Klamath Project

Hydrologic Alteration: In 1905, Reclamation began developing an irrigation project near Klamath Falls, Oregon. Marshes were drained, dikes and levees were constructed (NRC 2008), and the level of UKL was raised in 1922. Starting around 1912, construction and operation of the numerous facilities associated with Reclamation's Klamath Project altered the natural hydrographs of the Upper and lower Klamath River. Reclamation's Project now consists of an extensive system of canals, pumps, diversion structures, and dams capable of routing water to approximately 220,000 acres of irrigated farmlands in the upper Klamath River Basin.

Hecht and Kamman (1996) analyzed the hydrologic records for similar water years (pre- and post-Project) at several locations. The authors concluded that the timing of peak and base flows changed significantly after construction of the Project, and that the operation increases flows in October and November and decreases flows in the late spring and summer as measured at Keno, Seiad, and Klamath USGS gauge sites.

Klamath Project Water Quality Impacts: The LRDC and Klamath Straits Drain (KSD) discharge into the Klamath River in the impounded reach upstream of Keno Dam. ODEQ (2010) investigated the impact of discharge from LRDC and KSD to the Klamath River.

A number of studies have concluded that the Reclamation's Project is a net sink of nutrients in relation to the Klamath River (Rykbost and Charlton 2001, Danosky and Kaffka 2002). For example, in 2002 ODEQ Quality (2010) found that the Project appears to be a sink of nutrients in relation to the Klamath River (Figure 6-16).

Reclamation estimated nutrient loads diverted to and discharged from the Klamath Drainage District (KDD) for the period of April to November in 2000. These nutrient loading estimates showed that the nutrient loads contained in the water diverted to KDD through Ady and North Canals was much greater than the nutrient loads returned to the Klamath Straits Drain from KDD. Hence, KDD acts as a significant sink for ammonia, nitrate plus nitrite, total Kjeldahl nitrogen, orthophosphate, and total phosphorous. Table 6-9 summarizes 2000 nutrient loading to the upper Klamath River and the Project while Table 6-10 summarizes 2002 nutrient loading to the upper Klamath River and the Project.

However, ODEQ (2010) concluded, at least in 2002, that even though the Project appears to be a net sink of nutrients, it also appears to have detrimental impacts to the water quality of Klamath River. During May through October, Klamath Straits Drain discharge contributes approximately half the flow of the Klamath River at Keno Dam. Therefore, at least in 2002, its higher concentration of nutrients relative to the Klamath River increases the nutrient concentration of the Keno Impoundment reach (Figure 6-17).

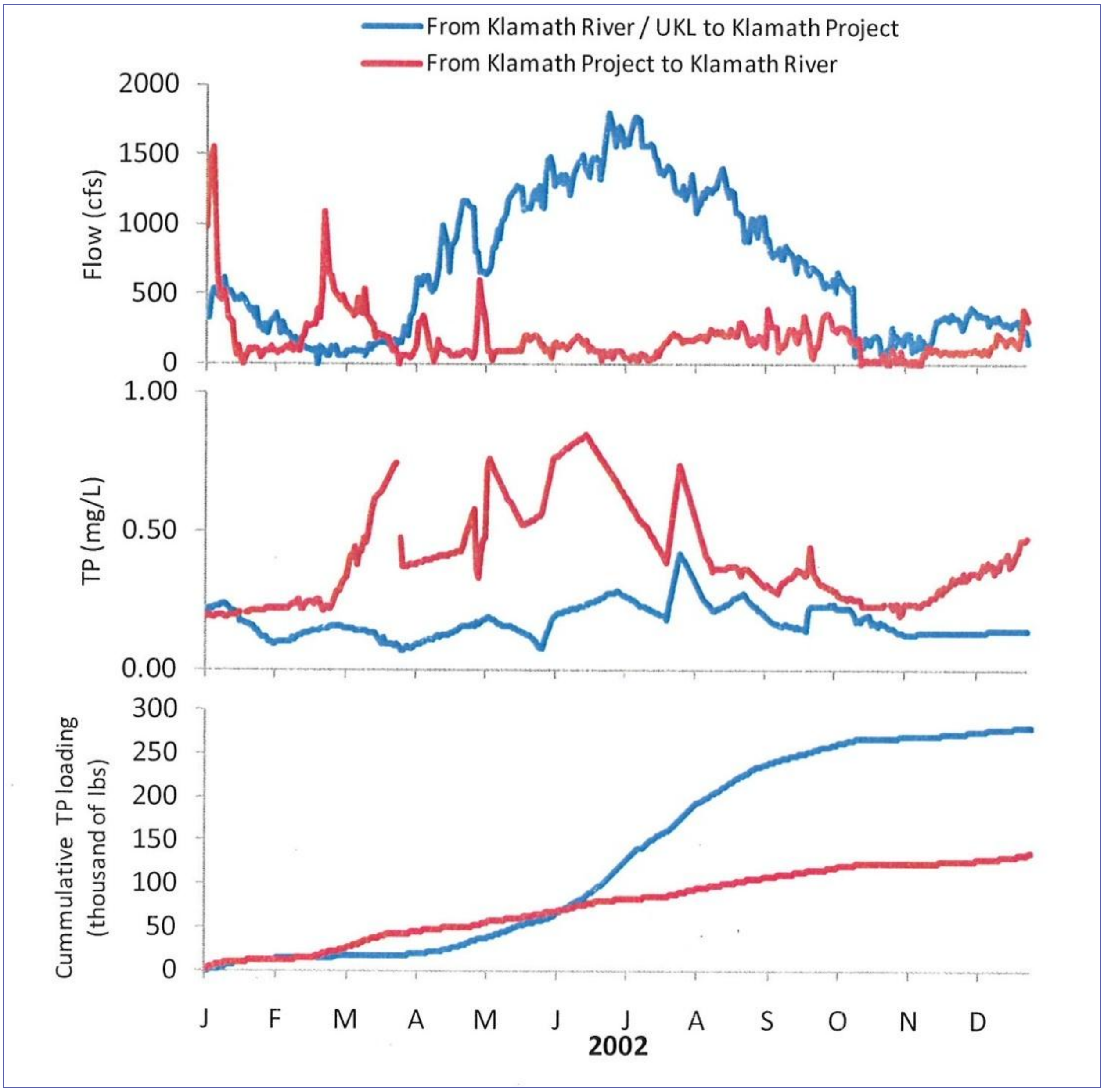

Figure 6-16. Flow, concentration and cumulative loading analysis of Bureau of Reclamation's Klamath Project. Total phosphorus (TP) concentrations weighted based on relative flow rates. *Source: Oregon Department of Environmental Quality 2010.*

Table 6-9. Upper Klamath Basin nutrient loading 2000.

Location	Ammonia (Metric Tons)	Nitrate plus Nitrite (Metric Tons)	Total Kjeldahl Nitrogen (Metric Tons)	Orthophosphate (Metric Tons)	Total Phosphorous (Metric Tons)
Nutrient Load of Klamath River					
Klamath River at Miller Island	246.7	335.0	1,108.3	115.5	171.2
Klamath River at Keno	237.6	243.3	882.1	115.3	165.0
Nutrient Load Diverted from the Klamath River to Klamath Drainage District (KDD) and Lower Klamath National Wildlife Refuge (LKNWR)					
North Canal	17.6	29.4	77.8	8.2	12.0
Ady Canal to KDD	22.1	41.1	97.0	9.6	14.6
Ady Canal to LKNWR	12.3	14.2	53.4	4.0	6.2
Total Load Diverted	52.0	84.7	228.2	21.8	32.8
Nutrient Loads for Tule Lake National Wildlife Refuge (TLNWR), LKNWR, and Klamath Straits Drain					
TLNWR Discharge	36.5	89.3	482.2	29.1	66.0
LKNWR Discharge	14.6	7.7	97.8	13.4	18.6
KSD at Hwy 97	32.4	39.7	128.8	22.5	30.3
Nutrient Load to Klamath Drainage District					
North and Ady Canals	39.7	70.5	174.8	17.8	26.7
Nutrient Load Contribution to Klamath Straits Drain (KSD) from Klamath Drainage District					
KDD to KSD	17.8	31.9	31.0	9.1	11.6
Nutrient Load Reduction Within the Klamath Drainage District					
Net Reduction	**-21.9**	**-38.6**	**-143.7**	**-8.7**	**-15.0**

All nutrient loads are estimates for the period of mid-April 2000 through mid-November 2000.

Table 6-10. Upper Klamath Basin nutrient loading 2002.

Location	Ammonia (Metric Tons)	Nitrate plus Nitrite (Metric Tons)	Total Kjeldahl Nitrogen (Metric Tons)	Orthophosphate (Metric Tons)	Total Phosphorous (Metric Tons)
Nutrient Load from UKL to the Klamath River					
UKL at Link Dam	107.0	26.3	778.4	41.4	81.6
Nutrient Load diverted to the Project from UKL and Klamath River					
A Canal	87.7	24.3	678.6	39.6	70.6
LRDC	16.3	4.7	131.0	5.8	14.2
North Canal	11.9	0.8	55.7	4.2	6.9
Ady Canal	17.4	2.2	113.7	8.0	14.2
Total Load to Klamath Project	133.2	32.1	978.9	57.6	105.9
Nutrient Load Returned to the Klamath River from the Project					
Klamath Straits Drain at Hwy 97	22.3	10.0	147.3	21.8	28.2
Nutrient Load Reduction Within the Project					
Net Reduction	**-110.9**	**-22.1**	**-831.6**	**-35.8**	**-77.7**

All nutrient loads, except for nitrate plus nitrite, are estimates for the period of mid-April 2002 through October 2002. Estimated nitrate plus nitrite loads are for the period of mid-April 2002 through mid-August 2002.

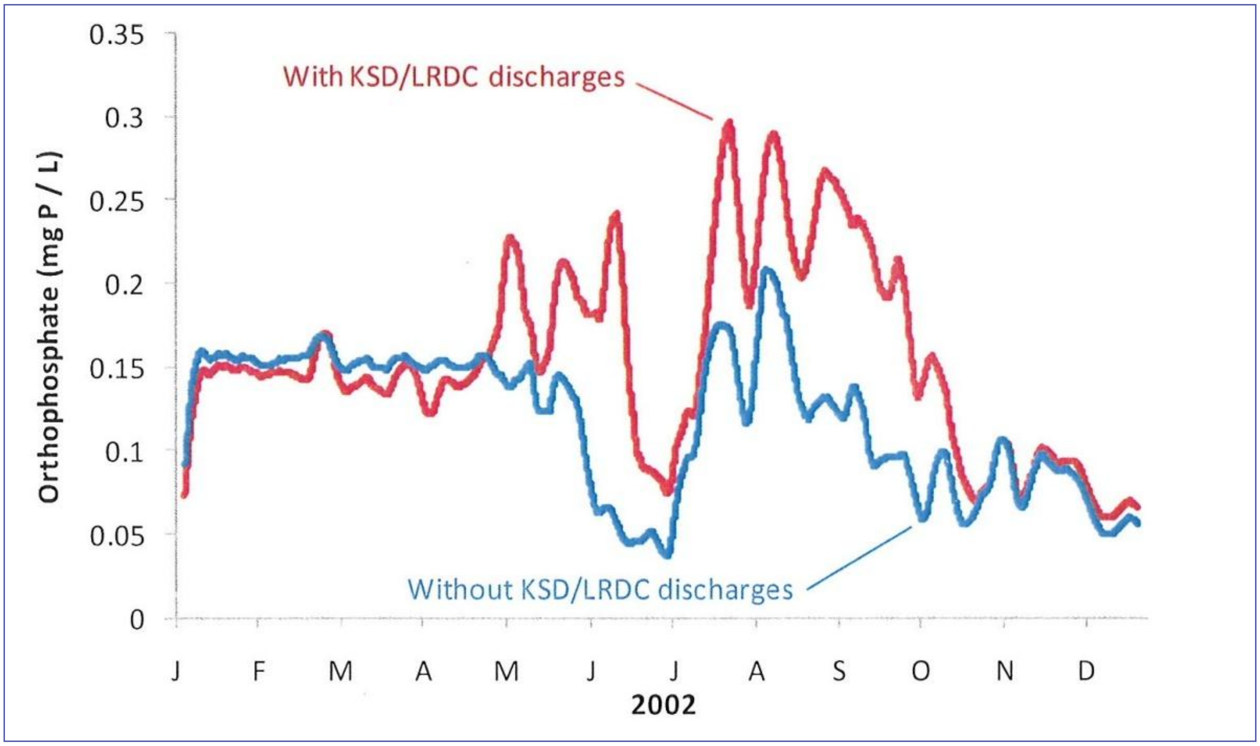

Figure 6-17. Klamath River model results from just downstream of Klamath Straits Drain discharge. *Source: Oregon Department of Environmental Quality 2010.*

6.3.2. SONCC Coho Salmon ESU Critical Habitat

Critical habitat for the SONCC coho salmon ESU includes all accessible waterways, substrate, and adjacent riparian zones between Cape Blanco, Oregon, and Punta Gorda, California (64 FR 24049; May 5, 1999). Excluded are:

1. Areas above specific dams identified in the FR notice;
2. Areas above longstanding natural impassible barriers (i.e., natural waterfalls); and,
3. Tribal lands.

The essential habitat types of SONCC coho salmon ESU designated critical habitat are:

1. Juvenile summer and winter rearing areas.
2. Juvenile migration corridors.
3. Adult migration corridors.
4. Spawning areas.
5. Areas for growth and development to adulthood.[28]

Within the five essential habitat types, essential features of coho salmon critical habitat include: adequate quantity and quality of substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions. In

[28] Areas for growth and development to adulthood is restricted to the marine environment for coho salmon, (NMFS 2010), and not impacted by the implementation of the Proposed Action.

addition, designated freshwater and estuarine critical habitat includes riparian areas that provide the following functions: shade, sediment, nutrient or chemical regulation, stream bank stability, and input of large woody debris or organic matter (64 FR 24049, May 5, 1999). Of these essential features, water quantity, water velocity, and habitat quantity are most impacted by implementing the Proposed Action.

6.3.2.1. Juvenile Summer and Winter Rearing Areas

Juvenile summer and winter rearing areas should contain adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, and space. These essential features are necessary to provide sufficient growth and reasonable likelihood of survival to smoltification. In the SONCC coho salmon ESU, juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient DO concentration levels, excessive nutrient loads, invasive species, habitat loss, disease effects, pH fluctuations, sedimentation, removal or non-recruitment of large woody debris, stream habitat simplification, and loss of riparian vegetation. Winter rearing areas suffer from high water velocities due to excessive surface runoff during storm events, increases in suspended sediment, removal or non-recruitment of large woody debris and stream habitat simplification. Changes to streambeds and substrate, as well as removal of riparian vegetation have limited the amount of invertebrate production in streams, which has in turn limited the amount of food available to rearing juveniles. Some streams in the ESU remain somewhat intact relative to their historical condition, but the majority of the waterways in the ESU fail to provide sufficient juvenile summer and winter rearing areas.

6.3.2.2. Juvenile Migration Corridors

Juvenile migration corridors need to have sufficient water quality, water quantity, water temperature, water velocity, and safe passage conditions in order for coho salmon juveniles and smolts to emigrate to estuaries and the ocean, or to redistribute into non-natal rearing zones. In the ESU, juvenile migration corridors suffer from low flow conditions, disease effects, high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution. Low DO levels, excessive nutrient loads, insufficient pH levels and other water quality factors also afflict juvenile migration corridors.

6.3.2.3. Adult Migration Corridors

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter and safe passage conditions in order for adults to reach spawning areas. Adults generally migrate in the fall or winter months to spawning areas. While adult migration corridors are a necessary step in the lifecycle for the species, the condition of this particular essential habitat type in the ESU is probably not as limiting, in terms of recovery of the species, as other essential habitat types, such as juvenile summer and winter rearing areas.

6.3.2.4. Spawning Areas

Spawning areas for SONCC coho salmon must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition, and egg-to-fry survival. Coho salmon spawn in smaller tributary streams from November through January in the ESU. A widespread problem throughout the ESU is sedimentation and embedding of spawning gravels, which makes redd building for adults difficult and decreases egg-to-fry survival. Excessive runoff from storms, which causes redd scouring, is another issue that plagues adult spawning areas. Low or non-recruitment of spawning gravels is common throughout the ESU, limiting the amount of spawning habitat.

6.3.2.5. SONCC Coho Salmon Critical Habitat Summary

The current function of critical habitat for SONCC coho salmon has been degraded relative to its unimpaired state. Although exceptions exist, the majority of streams and rivers in the ESU suffer from some combination of habitat degradation that limits the habitat's ability to adequately support one or more life stages of coho salmon. Additionally, critical habitat in the ESU often lacks the ability to establish essential features due to ongoing human activities. For example, water diversions reduce summer base flows in many systems throughout the ESU. The resulting lower flow volumes degrade several essential habitat features critical to juvenile coho salmon survival, such as water quality and water quantity.

Part 7 EFFECTS OF IMPLEMENTING THE PROPOSED ACTION ON LOST RIVER AND SHORTNOSE SUCKERS

Part 7 of the BA evaluates if implementing the Proposed Action may affect both Lost River and shortnose suckers and their designated critical habitat. Following this evaluation, Reclamation will make one of the following determinations for these ESA-listed species:

> "*No effect*" means there will be no impacts, positive or negative, to ESA-listed Lost River and shortnose suckers or their designated critical habitat. Generally, this means no Lost River and shortnose suckers or their designated critical habitat will be exposed to the Proposed Action and its environmental consequences.
>
> "*May affect, but not likely to adversely affect*" means that all effects are beneficial, insignificant, or discountable. Beneficial effects have contemporaneous positive effects without any adverse effects to Lost River and shortnose suckers or their designated critical habitat. Insignificant effects relate to the size of the impact and include those effects that are undetectable, not measurable, or cannot be evaluated. Discountable effects are those extremely unlikely to occur.
>
> "*May affect, and is likely to adversely affect*" means that Lost River and shortnose suckers or their designated critical habitat are likely to be exposed to the Proposed Action or its environmental consequences and will respond in a negative manner to the exposure.

Once a "may affect" determination is made, Reclamation must either request USFWS' and/or NMFS' concurrence with a "may affect, but not likely to adversely affect" finding or request initiation of formal ESA consultation if a "may affect, and is likely to adversely affect" is made. Upon completion of the formal consultation, USFWS and/or NMFS, through the issuance of a joint BO, will determine if implementing the Proposed Action causes jeopardy of the Lost River and shortnose suckers or adverse modification of their designated critical habitat.

Part 7 discusses the Proposed Action effects on individuals and populations of both Lost River and shortnose sucker species. When the discussion addresses effects to individuals and populations of both species, the generic expression "*suckers*" is used. When the discussion requires species differentiation, the text names the species of interest. This Part is organized by hydrologic watersheds of the Klamath River Basin and the Lost River Basin, closely emulating Recovery Units and management units proposed in the 2012 draft Recovery Plan for ESA-listed Klamath Basin suckers by the USFWS (76 FR 64372, 2011b, and described in the Environmental Baseline). The UKL Recovery Unit is comprised of the following management units: UKL and tributaries (river spawning), UKL (shoreline spawning), Keno Reservoir, and populations below Keno Dam. The Lost River Basin Recovery Unit is comprised of the following management units: Clear Lake Reservoir and tributaries, Tule Lake, Gerber Reservoir, and Lost River proper.

The Proposed Action is the continued operation of the Klamath Project including storage and delivery of irrigation water from bodies of water in the Upper Klamath Basin and O&M of canals, dams, and pumps consistent with water storage and delivery (*See* Section 4.3., Proposed Action). The Proposed Action includes an end of September UKL minimum target elevation of 4,138.1 (Table 4-6). To evaluate storage and delivery of surface water from UKL, hydrologic information during the past 31 water-years (October 1, 1980 to September 30, 2011) was modeled using WRIMS to simulate management decisions of the Proposed Action (*See* Section 3.1., Analytical Approach). WRIMS is a generalized water resources modeling system, broadly accepted by the hydrologic community, for evaluating operational alternatives of large, complex river basins. Resulting surface elevations for UKL from WRIMS were evaluated based on actual model output and exceedances of the modeled output. The modeled output informs resource managers on the expected outcomes to surface water (i.e., lake surface elevations and in-stream flows) that result from the Proposed Action. The Effects Analysis of the Proposed Action on suckers in UKL is conducted by reviewing information on lake surface elevation, impacts of lake surface elevation to sucker habitats at each life history stage, and direct impacts to individual suckers based on outputs from the model. The expected UKL elevation outcomes for the Proposed Action based on the 31-year Period of Record are shown in the exceedance tables for lake surface elevations. Review of model exceedance tables is beneficial to understanding expected frequency of occurrence for specific surface elevations. Model output was also reviewed for each model year, particularly for extreme dry conditions, to analyze the lowest range of likely lake surface elevations.

The Proposed Action includes the continued storage and delivery of irrigation water from Clear Lake Reservoir, Gerber Reservoir, Tule Lake, and Link to Keno Impoundment Reach of the Klamath River consistent with recent management including maintenance of surface elevations at or above biological minimum levels for each body of water. The Proposed Action contains a minimum September 30 surface elevation for each of Gerber and Clear Lake reservoirs. To ensure each lake is at or above the respective September 30 minimum surface elevation, information, such as inflow forecasts, evaporative and seepage estimates, and outflow measurements are considered during in-season management. In order to analyze the extent of impacts to endangered suckers at both locations resulting from the Proposed Action, a review of the historic surface elevations in conjunction with biological information at Gerber and Clear Lake Reservoirs is used to evaluate the frequency of lake elevations that are likely to occur.

The Proposed Action does not change existing surface elevations or biological minimums at Tule Lake and the Link to Keno Impoundment Reach of the Klamath River (i.e., Keno Reservoir) which is consistent with recent seasonal management of surface elevations at both locations. At Tule Lake Sump 1A, minimum surface elevations are maintained April through September to facilitate irrigation deliveries and protect endangered suckers. Minimum surface elevations are maintained October through March to protect endangered suckers (USFWS 1992). Surface elevations in the Link to Keno Impoundment Reach are maintained to facilitate irrigation and water operation infrastructure maintenance.

7.1. Effects to the Upper Klamath Lake Recovery Unit

7.1.1. Effects to UKL Individuals and Populations (Shoreline and Tributary) Habitat

The proposed management of UKL will affect habitat availability for each life history stage of the suckers, including larvae, YOY juveniles, older juveniles, and adults. Each sucker life history stage has different habitat needs and different critical seasons when they use certain habitats (Figure 7-1). This analysis evaluates the effect of lake management on the habitat associations of each life history stage in UKL and a discussion of other influential factors on suckers that may be linked to the proposed management of lake surface elevations.

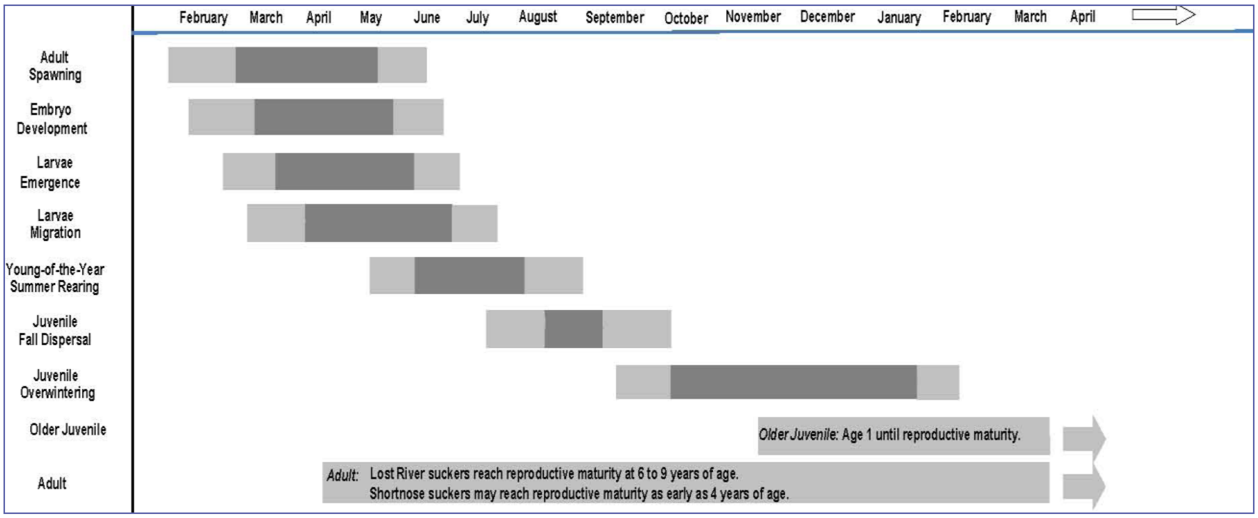

Figure 7-1. Each stage in the life history of suckers, such as spawning by adults, has a seasonal component of importance. For each life history stage or life cycle event in the figure below, dark shading indicates peak and light shading indicates off-peak activity or occurrence.

7.1.1.1. Effects to UKL Spawning Habitat

The Proposed Action continues to target high UKL surface elevations during sucker spawning from March through June with the maximum lake surface elevation attained each year in April or May (Table 7-1). Lake surface elevations by the end of April are at or above 4,142 feet in greater than 90 percent of years based on exceedances from the modeled output (Table 7-2). The Proposed Action results in one model year from the 31-year Period of Record analyzed (i.e., model year1992), in which the surface elevation of UKL failed to reach at least 4,142 feet by the end of April (Table 7-1). Based on lower recapture probabilities at the shoreline spawning areas in 2010 (Janey 2012, pers.comm.; Hewitt et al. 2012) when lake surface elevation was lower than 4,141.0 feet throughout much of the spawning season at the shoreline, it is assumed that a lake surface elevation at or above 4,142.0 feet by the end of April is beneficial to sucker shoreline spawning activity. This assumption is collaborated with survey data that the available shoreline spawning habitat inundated to a depth of at least 1.0 foot is about 74 percent at a surface elevation of 4,142.0 feet (Table 6-1). A review of modeled output of the Proposed Action (Table 7-1) indicates that the frequency at which reduced habitat may concentrate spawning or compel suckers to skip spawning at the shoreline areas due to the Proposed Action is relatively low (i.e., model year 1992 among the 31 years modeled). Assuming regular recruitment into populations, both Lost River and shortnose suckers have high reproductive output (Perkins et al. 2000a) that has the potential to offset occasional low reproduction years when conditions are poor with substantial gains in years when habitat conditions are good. However, regular recruitment into the adult populations of shortnose and Lost River suckers in UKL has been very low or altogether lacking for about 20 years (Hewitt et al. 2011, 2012).

The Proposed Action will occasionally result in low UKL surface elevations that will adversely impact adult spawning at the shoreline areas through a reduction of available spawning habitat. The impact is a reduction in the numbers of individual Lost River suckers that spawn at the shoreline spawning area.

Table 7-1. Upper Klamath Lake end of the month surface elevations (Reclamation datum, feet above mean sea level) for the Period of Record, water-year 1980 through water-year 2011, from modeled management decisions using the Proposed Action model run.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	4,142.0	4,142.4	4,142.8	4,143.2	4,142.9	4,142.1	4,141.2	4,140.1	4,139.2			
2010	4,140.8	4,141.7	4,142.3	4,142.7	4,142.5	4,141.8	4,140.7	4,139.4	4,138.9	4,139.0	4,139.7	4,140.7
2009	4,141.5	4,142.3	4,143.1	4,143.1	4,143.0	4,142.4	4,141.0	4,139.7	4,138.8	4,138.7	4,139.1	4,139.7
2008	4,141.5	4,142.3	4,143.1	4,143.3	4,143.0	4,142.2	4,140.7	4,139.6	4,138.8	4,138.8	4,139.6	4,140.3
2007	4,141.5	4,142.7	4,143.1	4,143.3	4,143.1	4,142.1	4,140.9	4,139.6	4,138.9	4,139.0	4,139.6	4,140.5
2006	4,141.4	4,142.1	4,142.8	4,143.3	4,142.9	4,142.0	4,141.0	4,139.8	4,139.0	4,139.0	4,139.8	4,140.8
2005	4,140.6	4,141.3	4,142.1	4,142.4	4,142.9	4,142.0	4,140.7	4,139.1	4,138.2	4,138.1	4,139.1	4,140.3
2004	4,141.0	4,142.3	4,143.1	4,143.3	4,143.0	4,142.0	4,140.7	4,139.4	4,138.6	4,138.4	4,138.8	4,139.8
2003	4,141.1	4,142.2	4,143.0	4,143.0	4,142.7	4,141.5	4,140.2	4,138.9	4,138.5	4,138.3	4,138.8	4,139.9
2002	4,141.4	4,142.4	4,143.1	4,143.3	4,142.8	4,141.8	4,140.4	4,139.1	4,138.4	4,138.2	4,138.7	4,139.5
2001	4,141.2	4,142.0	4,142.8	4,143.0	4,142.6	4,141.6	4,140.4	4,139.0	4,138.3	4,138.1	4,138.7	4,140.0
2000	4,141.8	4,142.4	4,142.8	4,143.3	4,143.2	4,142.2	4,140.9	4,139.6	4,139.4	4,138.9	4,139.4	4,140.3
1999	4,141.8	4,142.4	4,142.8	4,143.3	4,143.0	4,142.0	4,140.9	4,140.2	4,139.7	4,139.4	4,140.0	4,140.8
1998	4,141.6	4,142.4	4,142.8	4,143.2	4,143.3	4,142.6	4,141.7	4,140.6	4,140.0	4,140.0	4,140.5	4,141.1
1997	4,141.9	4,142.4	4,142.8	4,143.3	4,143.2	4,142.3	4,141.2	4,140.2	4,139.7	4,139.2	4,139.7	4,140.5
1996	4,141.9	4,142.4	4,142.8	4,143.3	4,143.3	4,142.5	4,141.1	4,140.0	4,139.4	4,139.3	4,139.9	4,140.9
1995	4,140.5	4,142.0	4,143.1	4,143.3	4,143.2	4,142.5	4,141.5	4,140.2	4,139.4	4,139.2	4,139.5	4,140.8
1994	4,141.5	4,142.0	4,142.6	4,142.6	4,142.3	4,141.4	4,140.1	4,138.9	4,138.3	4,138.1	4,138.7	4,139.4

Table 7-1. Upper Klamath Lake end of the month surface elevations (Reclamation datum, feet above mean sea level) for the Period of Record, water-year 1980 through water-year 2011, from modeled management decisions using Proposed Action Model Run.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993	4,140.1	4,140.8	4,142.7	4,143.3	4,143.1	4,142.7	4,141.4	4,140.4	4,139.6	4,139.7	4,139.8	4,140.6
1992	4,140.6	4,141.1	4,141.4	4,141.5	4,141.0	4,140.1	4,139.4	4,138.4	4,137.8	4,137.8	4,138.4	4,139.2
1991	4,140.8	4,141.6	4,142.4	4,142.6	4,142.4	4,141.5	4,140.5	4,139.4	4,138.9	4,138.6	4,139.1	4,139.8
1990	4,141.0	4,142.0	4,143.1	4,143.1	4,142.9	4,142.1	4,141.0	4,140.0	4,139.5	4,139.2	4,139.5	4,140.0
1989	4,141.5	4,142.2	4,142.8	4,143.3	4,143.0	4,142.1	4,140.5	4,139.2	4,138.8	4,138.6	4,138.9	4,139.8
1988	4,142.1	4,142.7	4,143.1	4,143.2	4,143.0	4,142.6	4,141.2	4,139.7	4,138.9	4,138.8	4,139.7	4,140.7
1987	4,141.8	4,142.6	4,143.1	4,143.3	4,143.1	4,142.4	4,141.6	4,140.3	4,139.7	4,139.4	4,139.8	4,141.0
1986	4,141.9	4,142.7	4,143.1	4,143.3	4,143.2	4,142.3	4,141.1	4,140.0	4,139.8	4,139.8	4,140.3	4,141.0
1985	4,142.0	4,142.4	4,142.8	4,143.3	4,143.0	4,142.3	4,140.9	4,140.1	4,140.1	4,139.9	4,140.3	4,141.1
1984	4,142.0	4,142.4	4,142.8	4,143.3	4,143.1	4,142.3	4,141.4	4,140.5	4,140.6	4,141.2	4,141.6	4,141.8
1983	4,142.0	4,142.4	4,142.8	4,143.2	4,142.7	4,141.8	4,141.2	4,140.5	4,140.3	4,140.6	4,141.4	4,141.8
1982	4,140.9	4,141.8	4,142.8	4,143.3	4,142.8	4,142.2	4,141.7	4,140.8	4,140.4	4,140.6	4,141.3	4,141.8
1981	4,141.7	4,142.7	4,143.1	4,143.2	4,143.0	4,142.2	4,140.8	4,139.2	4,138.2	4,138.0	4,139.0	4,139.9
1980										4,139.1	4,139.7	4,140.8

7.1.1.2. Effects to UKL Embryo Habitat

Based on a review of the model's output, the Proposed Action results in increasing lake elevations during late winter and spring, with a maximum annual lake elevation occurring in April or May of each year. Although a water depth requirement for successful embryo development is not known, the Proposed Action impacts embryo development through desiccation of spawning sites when surface elevations decline precipitously in May and early June, thus exposing embryos. Embryo survival at the highest elevation spawning sites, such as Ouxy and Silver Building Springs (Table 6-1), is most likely to be harmed by desiccation. Desiccation of spawning sites will adversely impact individual embryos and may adversely impact populations if a relatively high number of spawning sites become dewatered during embryo development. Based on review of modeled output, the Proposed Action impacts embryo development during dry conditions, such as conditions that occur at the 95 percent exceedance levels (Table 7-2).

Table 7-2. Exceedances of Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, February through June, for the Proposed Action. February through June is an important period for adult spawning and embryo survival at the shoreline spawning areas in UKL (Proposed Action model run).

Exceedance Level	February	March	April	May	June
95%	4,141.2	4,142.2	4,142.5	4,142.3	4,141.4
90%	4,141.6	4,142.4	4,142.6	4,142.5	4,141.5
85%	4,141.7	4,142.6	4,142.8	4,142.7	4,141.7
80%	4,142.0	4,142.8	4,143.0	4,142.7	4,141.8
75%	4,142.0	4,142.8	4,143.1	4,142.8	4,141.9
70%	4,142.0	4,142.8	4,143.2	4,142.9	4,142.0
65%	4,142.1	4,142.8	4,143.2	4,142.9	4,142.0
60%	4,142.2	4,142.8	4,143.2	4,142.9	4,142.1
55%	4,142.3	4,142.8	4,143.3	4,143.0	4,142.1
50%	4,142.3	4,142.8	4,143.3	4,143.0	4,142.1
45%	4,142.4	4,142.8	4,143.3	4,143.0	4,142.2
40%	4,142.4	4,142.8	4,143.3	4,143.0	4,142.2
35%	4,142.4	4,143.0	4,143.3	4,143.0	4,142.3
30%	4,142.4	4,143.1	4,143.3	4,143.1	4,142.3
25%	4,142.4	4,143.1	4,143.3	4,143.1	4,142.3

Table 7-2. Exceedances of Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, February through June, for the Proposed Action. February through June is an important period for adult spawning and embryo survival at the shoreline spawning areas in UKL (Proposed Action model run).

Exceedance Level	February	March	April	May	June
20%	4,142.4	4,143.1	4,143.3	4,143.1	4,142.4
15%	4,142.5	4,143.1	4,143.3	4,143.2	4,142.4
10%	4,142.7	4,143.1	4,143.3	4,143.2	4,142.5
5%	4,142.7	4,143.1	4,143.3	4,143.3	4,142.6

7.1.1.3. Effects to UKL Larval Sucker Habitat

Larval sucker habitat in UKL, especially for shortnose suckers, is generally shallow, near-shore areas, particularly with emergent vegetation (USFWS 2008a). This type of vegetation likely affords larval suckers with some protection from predators (Markle and Dunsmoor 2007), possibly more-diverse food resources (Cooperman and Markle 2004), and protection from turbulence during storm events (Klamath Tribes 1996). Larval suckers begin to appear in UKL in March, with peak abundance occurring in mid-May to mid-June. Larvae transform to juveniles by mid- to late July (Buchanan et al. 2011).

Although emergent wetland habitat exists at locations around UKL, wetlands at the Williamson River Delta are particularly important (USFWS 2008a). Wetlands at the Delta are adjacent to the major source of larvae emigrating from spawning areas in the Williamson and Sprague Rivers (Dunsmoor et al. 2000), and this area consistently has the highest densities of larvae in UKL during late spring surveys (Terwilliger et al. 2004).

The Proposed Action is anticipated to provide lake surface elevations at or above 4,141 feet by the end of June, and at or above 4,140 feet by the end of July in all but the driest years (Table 7-3). At 4,141 feet, approximately 70 percent of the emergent vegetation habitat in UKL is inundated to at least 1.0-foot water depth (Figure 6-2; based on data from Dunsmoor et al. (2000) and Reiser et al. (2001) prior to Williamson River Delta restoration activities). Even during dry conditions, such as when lake elevations are at the 95 percent exceedance level, it is anticipated that greater than 80 percent of emergent vegetation will be inundated by at least 1.0 foot of water through the end of June, and will drop to about 40 percent of available habitat by the end of July. Modeling of the Proposed Action resulted in one year from the 31-year Period of Record when the end of July lake surface elevation is below 4,140.0 feet (i.e., model year 1992; Table 7-1). Below 4,140.0 feet surface elevation there is less than 40 percent of emergent vegetation inundated to at least 1 foot. Even during the worst inflow scenario of 1992, the Proposed Action conserves small portions of emergent vegetation (at least 10 percent of habitat) as larval sucker habitat with surface elevations of 4141.0, 4140.1, and 4139.4 feet at the end of May, June, and July, respectively (Table 7-1).

Based on the available information, emergent vegetation appears important to the survival of larval suckers in UKL. While emergent vegetation likely provides multiple benefits to sucker larvae in UKL, both Clear Lake and Gerber Reservoir lack emergent vegetation. Consequently, while the evidence suggests emergent vegetation is beneficial to larval suckers, it may not be essential (USFWS 2008a). Numbers of larval suckers vary considerably from year to year and because of their small size, limited mobility and sensory capabilities, and dependence on relatively high food intake, are highly vulnerable to environmental factors, such as water temperature. Nevertheless, there is support for a conclusion that as the area of larval habitat of inundated emergent vegetation approaches zero it could reduce larval survival by exposing larvae to predators, increasing advection rates by exposing larvae to lake currents that could carry them to less favorable habitat, reducing feeding success, or exposing larvae to physical damage and mortality by wave action (USFWS 2008a). Based on wetland habitat inundation information by Dunsmoor et al. (2000) and Reiser et al. (2001) there will be little or no emergent vegetation habitat available at or below 4,139 feet; however, model output indicates that the Proposed Action avoids surface elevations below 4,139 feet during May, June, and July.

Table 7-3. Exceedances of UKL surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, April through July, for the proposed water management action. April through July is an important period for larval sucker habitat use of emergent vegetation in UKL (Proposed Action model run).

Exceedance Level	April	May	June	July
95%	4,142.5	4,142.3	4,141.4	4,140.1
90%	4,142.6	4,142.5	4,141.5	4,140.4
85%	4,142.8	4,142.7	4,141.7	4,140.5
80%	4,143.0	4,142.7	4,141.8	4,140.5
75%	4,143.1	4,142.8	4,141.9	4,140.7
70%	4,143.2	4,142.9	4,142.0	4,140.7
65%	4,143.2	4,142.9	4,142.0	4,140.8
60%	4,143.2	4,142.9	4,142.1	4,140.9
55%	4,143.3	4,143.0	4,142.1	4,140.9
50%	4,143.3	4,143.0	4,142.1	4,140.9
45%	4,143.3	4,143.0	4,142.2	4,141.0
40%	4,143.3	4,143.0	4,142.2	4,141.0
35%	4,143.3	4,143.0	4,142.3	4,141.1
30%	4,143.3	4,143.1	4,142.3	4,141.2
25%	4,143.3	4,143.1	4,142.3	4,141.2

Table 7-3. Exceedances of UKL surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, April through July, for the proposed water management action. April through July is an important period for larval sucker habitat use of emergent vegetation in UKL (Proposed Action model run).

Exceedance Level	April	May	June	July
20%	4,143.3	4,143.1	4,142.4	4,141.2
15%	4,143.3	4,143.2	4,142.4	4,141.4
10%	4,143.3	4,143.2	4,142.5	4,141.5
5%	4,143.3	4,143.3	4,142.6	4,141.6

The Proposed Action maintains at least 50 percent of inundated emergent vegetation habitat for larval suckers in UKL through to the end of June in each year except during model year 1992. During extended dry conditions, as in model years from the early 1990s, the Proposed Action still conserves a small percentage of inundated emergent vegetation through the end of July during model year 1992. The timeframe for potential future emergent vegetation to become fully established in the restored Williamson River Delta is uncertain; however, the increased area of wetland habitat will reduce the impacts to larval suckers from episodic low inflow years.

The Proposed Action provides substantial amounts of emergent vegetation inundated to at least a 1.0-foot depth through the end of July in all years except model year 1992 (Table 7-1). It is uncertain how many larval suckers would be produced during low inflow years or an extended drought. However, during extremely low inflow years, declining amounts of emergent vegetation habitat are still available to larval suckers in UKL through the end of June and into July, but this habitat will be reduced by the end of July during extended dry conditions based on model. The Proposed Action provides greater than 50 percent emergent vegetation habitat for larvae in all but the driest inflow years; however, the Proposed Action is anticipated to adversely impact larval sucker habitat in UKL.

7.1.1.4. Effects to UKL Young-of-the-Year Juvenile Habitat

When lake levels drop below about 4,140 feet, vegetated habitats preferred by larval suckers and, perhaps to lesser extent YOY juveniles, become dewatered and suckers must move to other habitats. In late summer, a surface elevation at or above 4,138.0 feet still allows juvenile access to near-shore, non-vegetated habitats with substrate diversity. As the lake recedes below 4,138.0 feet, juvenile access to rocky substrates becomes increasingly difficult as near-shore habitat transitions to fine sediments (Simon et al. 1995, Bradbury et al. 2004, Eilers and Eilers 2005). During late summer and early autumn, juveniles appear to leave near-shore areas as lake surface elevation is nearing its annual low point (Terwilliger 2006). It is not understood whether this seasonal movement by YOY suckers is related to decreasing near-shore habitats as lake surface elevation recedes (USFWS 2002), or other explanations such as a biological response to other environmental cues or changes in physiological demands during late summer (Reclamation 2007).

Lake surface elevations under the Proposed Action remain at or above 4,138.9 feet by the end of August and above 4,138.2 feet by the end of September (Table 7-4). Lake surface elevations by the end of September, nearing the end of the period when YOY juveniles are most prevalent in near-shore areas of UKL, are anticipated to be between 4,138.2 and 4,140.3 feet according to the modeling of the Proposed Action using the Period of Record (Table 7-4). The Proposed Action provides an end of September elevation of 4,138 feet. Surface elevations above 4,138 feet are assumed to provide sufficient diversity in nearshore substrates as habitats for YOY juvenile suckers based on nearshore substrate surveys (Simon et al. 1995, Bradbury et al. 2004, Eilers and Eilers 2005). However, there is one year of low inflow (i.e., model year 1992) in the Period of Record that the Proposed Action would result in an end of September surface elevation below 4,138 feet at 4,137.8 feet (Table 7-1). Adverse impact to YOY juvenile suckers through the reduction of substrate diversity in nearshore habitats can occur when surface elevations are below 4,138 feet. Under the Proposed Action, lake surface elevations are anticipated to be at or above 4138 feet by the end of September. During model year 1992, there is a loss of near-shore substrate diversity during late summer and early fall that may adversely impact YOY juvenile suckers.

Table 7-4. Exceedances of Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, July through September, under the Proposed Action.

Exceedance Level	July	August	September
95%	4,140.1	4,138.9	4,138.2
90%	4,140.4	4,139.0	4,138.3
85%	4,140.5	4,139.1	4,138.3
80%	4,140.5	4,139.2	4,138.5
75%	4,140.7	4,139.3	4,138.7
70%	4,140.7	4,139.4	4,138.8
65%	4,140.8	4,139.5	4,138.8
60%	4,140.9	4,139.6	4,138.9
55%	4,140.9	4,139.6	4,138.9
50%	4,140.9	4,139.7	4,139.0
45%	4,141.0	4,139.9	4,139.3
40%	4,141.0	4,140.0	4,139.4
35%	4,141.1	4,140.0	4,139.5
30%	4,141.2	4,140.1	4,139.6
25%	4,141.2	4,140.2	4,139.7

Table 7-4. Exceedances of Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, July through September, under the Proposed Action.

Exceedance Level	July	August	September
20%	4,141.2	4,140.2	4,139.7
15%	4,141.4	4,140.3	4,139.9
10%	4,141.5	4,140.5	4,140.1
5%	4,141.6	4,140.5	4,140.3

7.1.1.5. Effects to UKL Older Juveniles and Adult Habitat

As result of new information on UKL bathymetry (*See* Part 5 Environmental Baseline), both the amount and percent of open water habitat in the northern portion of UKL utilized by older juvenile and adult suckers during summer months appears to be greater than was previously known. The increase of lake area at preferred depth and percent of area at preferred depth is largely through improved bathymetry surveying with the addition of the reconnected Williamson River Delta (Tables 7-5 and 7-6) and without inclusion of the Delta (Tables 7-7 and 7-8).

During dry conditions at the 95 percent exceedance levels, the Proposed Action maintains UKL surface elevations above 4,138.2 feet by the end of each July, August, and September (Table 7-4). A surface elevation of 4,138.5 feet provides approximately 13,000 acres (about 46 percent of available habitat) in the portion of UKL north of Bare Island (Figure 5-2) at depth of 6.56 feet (2m) or greater without considering the inclusion of the reconnected Williamson River Delta (Tables 7-7 and 7-8). Assuming that conditions drier than those at the 95 percent exceedance level are experienced such as conditions of the early 1990s, it is anticipated the Proposed Action results in lake elevations that still provide greater than about 20 percent of available habitat in the northern end of UKL at depths between 6.56 and 9.84 feet (2 and 3m) through the end of September with or without the Delta reconnection (Tables 7-6 and 7-8). During conditions with inflow drier than the 95 percent exceedance level, such as1992, the Proposed Action maintains a surface elevation (feet above mean sea level [msl]) through to the end of September of 4,137.8 (Table 7-1). About 21 to 22 percent of the available habitat, or 6,300 acres, in the northern end of UKL within the preferred depths of 6.56 and 9.84 feet (2 and 3m) is available at a lake elevation of 4,137.5 feet with and without the inclusion of the reconnected Williamson River Delta (Tables 7-6 and 7-8).

Table 7-5. Area in acres of northern Upper Klamath Lake available by depth (meters) for a range of Lake surface elevations in North American Vertical Datum 88 and Reclamation datum (feet above mean sea level). Data includes reconnected Williamson River Delta and is from Navionics, LiDAR, and field surveys.

Lake surface elevation in North American Vertical Datum 88 (feet)	Lake surface elevation in Reclamation datum (feet)	Acres of Lake at depths between 0 and 1 meter	Acres of Lake at depths between 1 and 2 meters	Acres of Lake at depths between 2 and 3 meters	Acres of Lake at depths between 3 and 4 meters	Acres of Lake at depths > 4 meters
4,145.33	4,143.3	6,314.2	4,833.2	10,754.9	12,642.3	6,531.3
4,145.03	4,143.0	7,824.5	3,888.9	10,189.0	14,102.6	5,071.0
4,144.53	4,142.5	9,319.0	3,490.9	10,684.3	13,509.9	3,846.1
4,144.03	4,142.0	9,366.6	4,651.9	11,214.0	12,461.1	2,874.0
4,143.53	4,141.5	9,409.3	5,562.5	11,953.6	10,751.1	2,320.3
4,143.03	4,141.0	8,118.2	7,693.8	12,248.3	8,506.1	1,927.4
4,142.53	4,140.5	6,013.7	9,499.9	12,391.5	6,682.7	1,613.7
4,142.03	4,140.0	4,833.2	10,754.9	12,642.3	5,153.7	1,377.6
4,141.53	4,139.5	3,888.9	12,006.6	12,284.9	3,811.8	1,259.3
4,141.03	4,139.0	3,490.9	12,705.2	11,489.0	2,678.8	1,167.3
4,140.53	4,138.5	4,651.9	13,477.8	10,197.3	1,789.6	1,084.4
4,140.03	4,138.0	5,562.5	14,591.5	8,113.2	1,304.6	1,015.7
4,139.53	4,137.5	7,693.8	14,385.5	6,368.9	970.6	956.8
4,139.03	4,137.0	9,499.9	14,156.6	4,917.6	711.0	902.7

Surface elevations below 4,138.0 feet at the end of September may impact older juvenile and adult suckers by reducing the amount of open water habitat available in a preferred range of water depths. However, there is recent information that older juveniles may use nearshore, shallow habitats with some frequency along the western lake shore and near the Williamson River Delta, indicating depth may not be the only habitat feature utilized by older juvenile suckers in UKL (Burdick and VanderKooi 2010, Burdick 2012a, 2012b). The Proposed Action is not anticipated to create surface elevations below 4,138.0 feet except during dry conditions with low inflows as experienced in one year from the 31-year Period of Record (i.e., model year 1992). Suckers concentrated and confined in a relatively small area could experience increased incidences of disease, parasitism (especially lamprey), and bird predation (USFWS 2008a). It is also reasonable to assume that the resulting high densities of fish could deplete the remaining food supply, causing additional stress and possible mortality (USFWS 2008a). However, the effects of low surface elevations, and possible concentration of suckers into remaining habitats, on population size, age-class distribution, recruitment, or decreased individual condition are not fully understood.

Table 7-6. Percent area of northern Upper Klamath Lake available by depth (meters) for a range of Lake surface elevations in North American Vertical Datum 88 and Reclamation datum (feet above mean sea level). Data includes reconnected Williamson River Delta and is from Navionics, LiDAR, and field surveys.

Lake surface elevation in North American Vertical Datum 88 (feet)	Lake surface elevation in Reclamation datum (feet)	Acres of Lake at depths between 0 and 1 meter	Acres of Lake at depths between 1 and 2 meters	Acres of Lake at depths between 2 and 3 meters	Acres of Lake at depths between 3 and 4 meters	Acres of Lake at depths > 4 meters
4,145.33	4,143.3	15.4	11.8	26.2	30.8	15.9
4,145.03	4,143.0	19.0	9.5	24.8	34.3	12.3
4,144.53	4,142.5	22.8	8.5	26.2	33.1	9.4
4,144.03	4,142.0	23.1	11.5	27.6	30.7	7.1
4,143.53	4,141.5	23.5	13.9	29.9	26.9	5.8
4,143.03	4,141.0	21.1	20.0	31.8	22.1	5.0
4,142.53	4,140.5	16.6	26.2	34.2	18.5	4.5
4,142.03	4,140.0	13.9	30.9	36.4	14.8	4.0
4,141.53	4,139.5	11.7	36.1	36.9	11.5	3.8
4,141.03	4,139.0	11.1	40.3	36.4	8.5	3.7
4,140.53	4,138.5	14.9	43.2	32.7	5.7	3.5
4,140.03	4,138.0	18.2	47.7	26.5	4.3	3.3
4,139.53	4,137.5	25.3	47.4	21.0	3.2	3.1
4,139.03	4,137.0	31.5	46.9	16.3	2.4	3.0

It is anticipated that UKL surface elevations are less critical to adult suckers from November through March because suckers redistribute throughout the lake after water quality in the lake improves and lake levels increase through the winter (Banish et al. 2007, 2009, USFWS 2008a). A primary concern during the winter is low DO concentrations that could occur during prolonged ice cover, although un-ionized ammonia during ice cover is also a concern (USFWS 2008a). Water quality conditions during ice cover conditions on UKL are discussed in Section 6.2.1.3.1. of the Environmental Baseline, Water Quality: Upper Klamath Lake.

The Proposed Action results in one model year below 4138 feet (e.g., model year 1992) where loss of habitat will have adverse impacts to older juvenile and adult suckers.

Table 7-7. Area in acres of northern Upper Klamath Lake available by depth (meters) for a range of Lake surface elevations in North American Vertical Datum 88 and Reclamation datum (feet above mean sea level). Data does not include Williamson River Delta and is from Navionics, LiDAR, and field surveys.

Lake surface elevation in North American Vertical Datum 88 (feet)	Lake surface elevation in Reclamation datum (feet)	Acres of Lake at depths between 0 and 1 meter	Acres of Lake at depths between 1 and 2 meters	Acres of Lake at depths between 2 and 3 meters	Acres of Lake at depths between 3 and 4 meters	Acres of Lake at depths > 4 meters
4,145.33	4,143.3	5,135.9	2,724.3	9,081.9	12,212.0	6,530.6
4,145.03	4,143.0	6,075.0	2,228.5	8,638.5	13,671.8	5,070.9
4,144.53	4,142.5	7,139.4	2,238.2	9,092.4	13,257.6	3,846.0
4,144.03	4,142.0	7,098.4	3,533.3	9,482.1	12,450.8	2,874.0
4,143.53	4,141.5	6,805.3	4,857.3	10,325.0	10,744.4	2,320.3
4,143.03	4,141.0	5,581.2	6,594.0	11,120.9	8,502.0	1,927.4
4,142.53	4,140.5	3,602.3	7,960.9	11,765.1	6,680.6	1,613.7
4,142.03	4,140.0	2,724.3	9,081.9	12,212.0	5,153.0	1,377.6
4,141.53	4,139.5	2,228.5	10,277.6	12,032.8	3,811.6	1,259.3
4,141.03	4,139.0	2,238.2	10,871.3	11,478.7	2,678.8	1,167.3
4,140.53	4,138.5	3,533.3	11,742.1	10,190.7	1,789.6	1,084.4
4,140.03	4,138.0	4,857.3	12,960.3	8,109.1	1,304.6	1,015.7
4,139.53	4,137.5	6,594.0	13,256.1	6,366.9	970.6	956.8
4,139.03	4,137.0	7,960.9	13,528.8	4,917.0	711.0	902.7

Table 7-8. Percent area of northern Upper Klamath Lake available by depth (meters) for a range of Lake surface elevations in North American Vertical Datum 88 and Reclamation datum (feet above mean sea level). Data does not include Williamson River Delta and is from Navionics, LiDAR, and field surveys.

Lake surface elevation in North American Vertical Datum 88 (feet)	Lake surface elevation in Reclamation datum (feet)	Acres of Lake at depths between 0 and 1 meter	Acres of Lake at depths between 1 and 2 meters	Acres of Lake at depths between 2 and 3 meters	Acres of Lake at depths between 3 and 4 meters	Acres of Lake at depths > 4 meters
4,145.33	4,143.3	14.4	7.6	25.5	34.2	18.3
4,145.03	4,143.0	17.0	6.2	24.2	38.3	14.2
4,144.53	4,142.5	20.1	6.3	25.6	37.3	10.8
4,144.03	4,142.0	20.0	10.0	26.8	35.1	8.1
4,143.53	4,141.5	19.4	13.9	29.5	30.7	6.6
4,143.03	4,141.0	16.5	19.6	33.0	25.2	5.7
4,142.53	4,140.5	11.4	25.2	37.2	21.1	5.1
4,142.03	4,140.0	8.9	29.7	40.0	16.9	4.5
4,141.53	4,139.5	7.5	34.7	40.6	12.9	4.3
4,141.03	4,139.0	7.9	38.2	40.4	9.4	4.1
4,140.53	4,138.5	12.5	41.4	36.0	6.3	3.8
4,140.03	4,138.0	17.2	45.9	28.7	4.6	3.6
4,139.53	4,137.5	23.4	47.1	22.6	3.4	3.4
4,139.03	4,137.0	28.4	48.3	17.5	2.5	3.2

Table 7-9. Exceedances of Upper Klamath Lake surface elevations (feet above mean sea level, Reclamation datum) anticipated for end of months, July through September, under the Proposed Action. July through September is an important period for access to water quality refuge areas near Fish Banks and Pelican Bay and to deep water habitats in the northern area of UKL by older juvenile and adult suckers. (Proposed Action Model Run)

Exceedance Level	July	August	September
95%	4,140.1	4,138.9	4,138.2
90%	4,140.4	4,139.0	4,138.3
85%	4,140.5	4,139.1	4,138.3
80%	4,140.5	4,139.2	4,138.5
75%	4,140.7	4,139.3	4,138.7
70%	4,140.7	4,139.4	4,138.8
65%	4,140.8	4,139.5	4,138.8
60%	4,140.9	4,139.6	4,138.9
55%	4,140.9	4,139.6	4,138.9
50%	4,140.9	4,139.7	4,139.0
45%	4,141.0	4,139.9	4,139.3
40%	4,141.0	4,140.0	4,139.4
35%	4,141.1	4,140.0	4,139.5
30%	4,141.2	4,140.1	4,139.6
25%	4,141.2	4,140.2	4,139.7
20%	4,141.2	4,140.2	4,139.7
15%	4,141.4	4,140.3	4,139.9
10%	4,141.5	4,140.5	4,140.1
5%	4,141.6	4,140.5	4,140.3

7.1.1.5.1. Effects to Adult Sucker Access to UKL Areas of Refuge from Poor Water Quality

During dry conditions, such as those at the 95 percent exceedance level, the Proposed Action maintains lake surface elevations above 4,138.2 feet by the end of July, August, and September (Table 7-9). This surface elevation provides approximately 4.75 feet (1.45m) water depth in Fish Banks and the channel to Pelican Bay assuming an average depth at these locations of

4,133.0 feet. During drier conditions, the Proposed Action results in end of September surface elevations as low as 4,137.8 feet in 1992 (Table 7-1). Surface elevations below this measure, although rare based on results of the Proposed Action, pose a risk to individual suckers if they are unable to seek refuge in Pelican Bay through water less than four feet during seasonally stressful water quality events. However, recent refinements in UKL bathymetry (explained in Section 7.1.1.5., Older Juveniles and Adult Habitat) indicate that water depth may be adequate for sucker access at Fish Banks and in the access channel into Pelican Bay during most summer months (Tables 7-9 and 7-10). The lake bottom in the Fish Banks area and in the channel connecting Pelican Bay and UKL is between 4,132.0 and 4,133.5 feet elevation (Reclamation datum) based on the improved bathymetry of the area. Lake elevations higher than 4,137.5 feet indicate suckers have water depth of four feet (1.22m) assuming that the access channel to Pelican Bay and the Fish Banks area has a lake bottom elevation of 4,133.0 feet (Tables 7-9 and 7-10). The impact of reduced access to areas of water quality refuge to individual suckers is through possible reduced body condition or mortality from exposure to stressful or acutely-toxic water quality conditions.

Table 7-10. Older juvenile and adult sucker access to areas of water quality refuge during summer months in Upper Klamath Lake is related to Lake surface elevations.

Lake surface elevation (North American Vertical Datum 88)	Lake surface elevation (Reclamation Datum)	Depth of Fish Banks and Depth of Access to Pelican Bay with Lake Bottom at 4,133.5 feet (Reclamation Datum)
4,145.03	4,143.0	9.5
4,144.53	4,142.5	9.0
4,144.03	4,142.0	8.5
4,143.53	4,141.5	8.0
4,143.03	4,141.0	7.5
4,142.53	4,140.5	7.0
4,142.03	4,140.0	6.5
4,141.53	4,139.5	6.0
4,141.03	4,139.0	5.5
4,140.53	4,138.5	5.0
4,140.03	4,138.0	4.5
4,139.53	4,137.5	4.0
4,139.03	4,137.0	3.5

7.1.1.6. Effects to Water Quality

In recent decades, the lake has experienced serious water quality problems that have resulted in massive fish die-offs, as well as pronounced re-distribution of fish in response to declines in water quality (Buettner and Scoppetonne 1990, Banish et al. 2007, 2009). Considering that intense AFA blooms have been attributed to causing the poor water quality conditions in UKL (Bortleson and Fretwell 1993, Kann 1998, Risley and Laenen 1999, Perkins et al. 2000b, Eilers et al. 2004, Wood et al. 2006, Kuwabara et al. 2007, Morace 2007), the effect of lake level on algal biomass is of particular importance. Analysis of existing data found no relationships between AFA densities (represented by chlorophyll concentration) and extremes of DO and pH with depth in UKL (NRC 2002). Other analyses suggest that climatic conditions may have a greater influence on UKL water quality than lake level and the other variables considered (Wood et al. 1996, Morace 2007). Water depth may have an effect on water quality, but existing data and analyses have not shown a discernible relationship between UKL elevation and water quality over the range of depths that UKL has been operated at during the period from 1990 through 2006 (Reclamation 2007).

Information indicates adverse water quality and fish disease impact suckers in UKL at both the individual and the population levels (Perkins et al. 2000b). The Proposed Action is not anticipated to influence water quality or fish disease in UKL aside from the possibility of periodic, but infrequent, concentrating of fish in limited habitat during late summer months when disease could be more-readily spread among individuals (*See* Older Juveniles and Adult Habitat, Sucker Access to Water Quality Refugia Baseline). Furthermore, there have been no known large winter fish die-offs documented in UKL (Buettner 2007, pers. comm. cited in USFWS 2008a). The Proposed Action is not anticipated to impact water quality conditions for suckers during under ice cover conditions.

7.1.1.7. Entrainment Losses from UKL

The Proposed Action will adversely impact larvae, YOY juvenile, and both older juvenile and adult suckers through entrainment in diverted water through numerous diversion points, principally at A Canal and Link River Dam. The numbers of suckers at each life history stage will vary annually dependent on the amount of water transported and the numbers of suckers exposed to entrainment at each life history stage, a function of annual sucker production at earliest life history stages, and perhaps other factors such as wind speed and direction and water quality. Relatively low numbers of older juvenile and adult suckers entrained from UKL are anticipated (Gutermuth et al. 2000a, 2000b, USFWS 2007c, 2008, Tyler 2012a, 2012b). A summary of diversion locations and approximate water delivery at each location within the boundaries of the Klamath Project was previously provided by Reclamation (2001b). Estimated numbers of larval and YOY juvenile suckers entrained each year are also variable but with relatively high entrainment estimates that extend up to several million larvae and several hundred thousand YOY juveniles (Gutermuth et al. 2000a, 2000b, USFWS 2007c, Tyler 2012b).

7.1.2. Keno Reservoir and Below Keno Dam Individuals and Populations

Reclamation’s responsibility below Keno is the release of UKL surface water at the Link River Dam for downstream needs discussed elsewhere in this document. The flows are anticipated to provide adequate habitat to individual suckers that reside in reservoirs below Keno Dam. Impacts of any potential take of listed suckers below Keno Dam resulting from degradation and loss of habitat due to low instream flows on the overall population is likely low (PacifiCorp 2012). This is consistent with USFWS’ conclusions contained in the 2007 BO (USFWS 2007c) that indicated that while PacifiCorp’s current operation of developments and associated minimum instream flow requirements below Keno, J.C. Boyle, and Copco No. 2 dams may affect individual suckers in this area, these effects are minimal within the context of the overall population size and geographic range of the Lost River and shortnose sucker. These reaches are not part of the original habitat complex of the listed suckers and are inherently unsuitable for completion of life cycles of these suckers (USFWS 2007c). The focus of this section will be on the Link River and the Link to Keno Impoundment Reach of the Klamath River where the Project has the greatest influence, through water operations, on the two endangered sucker species.

7.1.2.1. Effects to Keno and Downriver Spawning Access and Fish Passage

No known spawning habitat exists in the Klamath River downstream of the Link River mouth to the Keno Dam (Buchanan et al. 2011). Spawning activity in the lower Link River, upstream of the West Side hydropower facility, was observed during May 2007 (Smith and Tinniswood 2007). The Proposed Action includes the release of surface water from UKL through the Link River Dam for downstream needs. The Proposed Action which includes slightly higher releases from the Link River Dam during spring months may beneficially impact spawning and passage in the Link River. However, higher flows and velocities may also hinder sucker passage in the Link River.

7.1.2.2. Effects to Keno and Downriver Young-of-the-Year Juvenile Habitat

All life stages of listed suckers have been found in the Link River in recent years, based on monitoring below UKL and the Link River Dam. This habitat is primarily a migration corridor for large numbers of larval and juvenile suckers dispersing downstream from UKL to the Link to Keno Impoundment Reach (Gutermuth et al. 2000b, Foster and Bennetts 2006).

The Link to Keno Impoundment Reach of the Klamath River is relatively shallow (average depth of 7.5 feet) and long (22.5 miles), and receives most of its water from UKL via the Link River (PacifiCorp 2012). Substantial quantities of water are also diverted from, and discharged to, the Link to Keno Impoundment Reach through and from facilities managed by Reclamation and several private permit holders (USFWS 2007c). A summary of diversion locations and approximate quantities is provided in Reclamation (2001b).

YOY juvenile suckers in Link to Keno Impoundment Reach of the Klamath River likely use near-shore habitats of emergent vegetation or the transition zones between vegetation and open water. More YOY juvenile suckers were captured in trap nets fished close to the shoreline near emergent vegetation than in open water areas in Lake Ewauna of the Link to Keno Impoundment Reach (Tyler and Kyger 2012). Furthermore, sampling in a reconnected wetland bordered by North and Ady canals captured more YOY juvenile suckers in transition zones near emergent vegetation than in open water or in vegetation (Phillips et al. 2011).

The Proposed Action maintains a surface elevation in this reach of 4,086.5 feet except for one to four days during March or April, when the surface elevation is drawn down two additional feet to facilitate maintenance of irrigation infrastructure. This operation is consistent with past operations of surface elevations in the Link to Keno Impoundment Reach of the Klamath River. The ongoing management to operate for stable surface elevations in the Link to Keno Impoundment Reach of the Klamath River impacts development of additional wetland habitats and degrades the quality of existing wetlands through controlled water depth (USFWS 2007c). However, stable surface elevations do provide sucker access to the established wetland habitats for rearing during sucker early life history stages. The brief duration of the annual drawdown is not anticipated to impact the amount of near shore or transition habitats used by YOY juvenile suckers. The Proposed Action has minor effect on YOY juvenile habitat in the Link to Keno Impoundment Reach.

7.1.2.3. Effects to Keno and Downriver Older Juveniles and Adults Habitat

Little is known about habitat use in the Link to Keno Impoundment Reach of the Klamath River by older juvenile and adult suckers. Limited available information suggests adult suckers still migrate into the Link River during the spring and summer (Piaskowski 2003, Wilkens and Kyger 2011), and at least juveniles apparently reside in the Link River, Lake Ewauna, and/or the Keno Impoundment below the Link River Dam throughout most of the year (USFWS 2002, Phillips et al. 2011). Recent efforts to evaluate sucker passage at the Link River fish ladder has observed congregations of adult suckers in Lake Ewauna near the Link River during late winter and spring months (Wilkens and Kyger 2011, 2012 draft report). However, this effort did not survey elsewhere in the Link to Keno Impoundment Reach for adult suckers at that time of year or attempt to define adult sucker habitat in Lake Ewauna. The relatively low number of tagged adult suckers detected at the Link River fish ladder and the relatively high recapture of tagged suckers in the Link to Keno Impoundment Reach, in relationship to the numbers of adult suckers that were tagged in 2008 through 2010 (Kyger and Wilkens 2011) suggests adult suckers do not exit the Link to Keno Impoundment Reach in high numbers or with much frequency. It is likely that older juvenile and adult suckers in the Link to Keno Impoundment Reach of the Klamath River occupy similar habitats as sucker in UKL, such as areas that provide depth and access to water quality refuge. The lower Link River is an important water quality refuge area for juvenile and adult suckers during periods of low DO in the Link to Keno Impoundment Reach (USFWS 2007c). It is assumed that older juveniles and adult suckers in the Link to Keno Impoundment Reach utilize water depth as they do in UKL.

The Proposed Action will not impact offshore, deeper habitats available to older juvenile and adult suckers. The Proposed Action is not anticipated to appreciably impact flows in the Link River during summer months when suckers use the lower Link River as water quality refuge.

7.1.2.4. Effects to Keno and Downriver Water Quality

Despite the relatively high tolerance for poor water quality by Lost River and shortnose suckers, suckers are likely affected by impaired summer water quality in the Link to Keno Impoundment Reach of the Klamath River Reservoir (NRC 2004, Saiki et al. 1999). The Proposed Action of continued surface water releases from UKL to this reach for Project irrigators and other downstream needs influences water quality in the Link to Keno Impoundment Reach.

Two sources of nutrients into the Link to Keno Impoundment Reach of the Klamath River from the Project include the LRDC and the Klamath Straits Drain. Water returning to the Klamath River from these sources contains nutrients, organics, and sediment. The use of agrochemicals on Project lands, particularly fertilizers, may increase nutrient concentrations on flows returning to the Klamath River via the LRDC and the Klamath Straits Drain. However, the quality of water entering, within, and leaving the Link to Keno Impoundment Reach is largely due to poor quality water entering from UKL containing large amounts of organic matter with an associated high BOD (Doyle and Lynch 2005, Deas and Vaughn 2006). Poor water quality events in the Link to Keno Impoundment Reach impact suckers that reside there. Quantifying the role of return flows in creating adverse water quality events is difficult to ascertain, because the eutrophic outflow from UKL confounds the ability to separate water quality effects of the Project from other factors. However, the increased concentration of nutrients on return flows as compared to ambient conditions is identified as contributing to poor water quality (ODEQ 2010). The Proposed Action likely has some impact to water quality in the Link to Keno Impoundment Reach of the Klamath River, but this impact is obscured by the volume of nutrient and organic matter arriving from UKL.

7.1.2.5. Entrainment Losses Keno and Downriver

Unscreened diversions from the Link to Keno Impoundment Reach of the Klamath River have an adverse impact to individual suckers at each life history stage. The impacts due to the loss of larval, juvenile, and adult suckers are uncertain (PacifiCorp 2012) but the magnitude of impacts is likely related to the amount of water diverted and both the seasonal and diurnal timing of diversions.

7.2. Lost River Basin Recovery Unit

The Lost River Basin Recovery Unit is comprised of the following management units: Clear Lake Reservoir and tributaries, Tule Lake, Gerber Reservoir and tributaries, and Lost River proper (USFWS 2011b). Information on early sucker life history ecology and habitat use within the Lost River watershed, particularly Tule Lake, Lost River, and both Clear Lake and Gerber Reservoirs, is sparse. Given a lack of direct observations, larval sucker ecology in the Lost River watershed is assumed similar as observations from UKL, except for the use of emergent vegetation by larval suckers in some lake environments lacking this habitat. Permanent emergent vegetation is generally scarce or absent along the shorelines of Clear Lake and Gerber Reservoirs (Reclamation 2002). It is possible that high turbidity at both of these locations provides cover to early sucker life history stages (USFWS 2008a).

7.2.1. Clear Lake Reservoir Individuals and Populations

Management of Clear Lake Reservoir under the Proposed Action will continue the on-going operation to provide for a minimum surface elevation of no less than 4,520.6 feet above msl on September 30 each year. Similar to processes described in past consultations (USFWS 2002, 2003), about April 1 of each year, the current April through September inflow forecast, current Reservoir elevation, estimated leakage and evaporative losses, and an end of September minimum elevation of 4,520.6 feet are used to determine available irrigation water from Clear Lake Reservoir. The amount of irrigation water available is periodically updated with new inflow forecasts and surface elevations as the irrigation season progresses. In-season updates inform the decisions to curtail or terminate irrigation deliveries to avoid going below the minimum surface elevation.

The effects of low water elevations and potential entrainment losses on population size, age-class distribution, recruitment, or decreased individual body condition are not fully understood. However, available information indicates that the Clear Lake sucker populations have remained viable under the current management of the lake (USFWS 2008a).

7.2.1.1. Effects to Clear Lake Adult Spawning and Migration

Low lake levels can adversely affect Lost River and shortnose suckers by limiting access to Willow Creek (USFWS 2002, 2008a). The Proposed Action to store and divert surface water from Clear Lake Reservoir while maintaining an end of September minimum surface elevation of 4520.6 feet each year may adversely impact adult suckers by periodically limiting access to Willow Creek during drought conditions. The magnitude of the impacts to individual suckers and the populations of suckers in Clear Lake are difficult to evaluate as a result of the Proposed Action, the high seepage and evaporative losses, and the sporadic nature of inflows at Clear Lake Reservoir through Willow Creek, as adult suckers appear to enter the creek on a combined cue of creek discharge and lake elevation. (*See* Section 6.2.1.2.2., Habitats in the Lost River Recovery Unit.)

7.2.1.2. Effects to Clear Lake Habitat for Larvae and Young-of-the-Year Juveniles

At Clear Lake Reservoir, larval and YOY juvenile suckers likely utilize habitat similar to older juveniles and adults including depth, surface area, and areas near-shore. Earlier life history stages may show more association with the shoreline at Clear Lake Reservoir than later stages; however, shoreline and lake surface area both decrease with reduced surface elevations. Thus, the description of lake surface area and depth as habitat for adult suckers is applicable to larvae and both YOY and older juveniles (*See* Section 7.2.2.3., Effects to Gerber Reservoir Habitat for Older Juvenile and Adult Suckers).

7.2.1.3. Effects to Clear Lake Habitat for Older Juveniles and Adults

The Proposed Action of a minimum surface elevation of 4,520.6 feet at the end of September preserves a lake surface area of approximately 41,150 acres. At this surface elevation, what remains of the east lobe has a water depth of about less than one foot, except for the pool nearest the dam into which Willow Creek flows. The surface area and depths at 4,520.6 feet represent the lowest habitat except for extreme, multiple-year droughts such as occurred during the 1930s. During the majority of months and years, surface elevations are anticipated to be above surface elevations that substantially impact older juveniles and adult suckers through reduced habitat (Table 6-3). However, the Proposed Action is anticipated to adversely impact older juvenile and adult suckers by reducing habitat availability, particularly lake surface area and depth, during infrequent periods of prolonged drought. During consecutive years of low inflow, individual suckers may experience reduced body condition, which can lead to mortality, and populations may contract in size if substantial numbers of adults are lost to mortality or individual reproductive health is compromised to the point that there is a reduction in recruitment.

7.2.1.4. Effects to Clear Lake Water Quality as Habitat

At Clear Lake Reservoir, lower water levels may result in degraded water quality, particularly higher water temperatures and lower DO. However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (Reclamation 1994a, 2000, 2001, 2007).

Very low lake levels in Clear Lake Reservoir pose an unquantified risk to listed suckers from adverse water quality (USFWS 2008a). In October 1992, the water surface elevation of Clear Lake was as low as 4,519.4 feet before the onset of a hard winter, and no fish die-offs were observed, although suckers showed poor condition factors in the following spring (Reclamation

1994a). It is uncertain if water quality conditions or crowding and competition for resources were responsible for impacts to suckers following winter 1992-1993.

The proposed lake level for Clear Lake at the start of the winter period from October to February is 4,520.6 feet. This elevation is anticipated to provide adequate water depths for protection against winter-kill of suckers (USFWS 2008a). Implementation of the Proposed Action is not anticipated to substantially impact water quality as sucker habitat in Clear Lake Reservoir.

7.2.1.5. Effects of Entrainment Losses at Clear Lake

The outlet at Clear Lake Dam is screened against fish entrainment. The screen was designed for a fish approach velocity not to exceed 0.75 feet/s, and with a mesh size no larger than 1/4 inch. The required total area of the fish screens was determined based on a flow of 200 cfs and the above screening criteria. With full screen submergence and a discharge of 200 cfs, the screen approach velocity is approximately 0.53 feet/s. Reclamation assumes no downstream losses of all fish greater than about 35 mm TL. It is assumed that YOY juvenile suckers attain this size in Clear Lake Reservoir by about July of each year based on larval and juvenile emigration sampling in Willow Creek (Scoppettone et al. 1995). Entrainment of older juvenile and adult suckers at the dam is prevented by the fish screen. Older juveniles and adult suckers may become impinged on the fish screen; however, the screen was designed with a maximum approach velocity intended to prevent impingement.

Periodically, fish stranding of all sucker life history stages has occurred in Clear Lake Reservoir. During water delivery in 2009, the pool of water nearest the dam became disconnected from the east lobe of Clear Lake Reservoir when the lake reached a surface elevation of about 4,522.0 feet in July. Forty-eight juvenile suckers (fork lengths between 86 and 132 mm) were captured and released to the west lobe of Clear Lake and three adult sucker mortalities were observed from late July through mid-August before water temperatures and DO concentrations improved in September (Reclamation, unpublished data). The pool nearest the dam is the only area identified at Clear Lake Reservoir that poses a stranding risk.

Fish smaller than about 35 mm TL may become entrained through the fish screen at Clear Lake Dam. Entrainment of small fishes, including suckers, at Clear Lake Dam has not been measured, however, Willow Creek’s close proximity to Clear Lake Dam and the overlap between the seasonal timing of larval sucker emigration from the creek and irrigation deliveries suggest that larval and small YOY juvenile sucker are susceptible to entrainment at Clear Lake Dam in May, June, and early July. Entrainment losses of larval and small juvenile suckers, although unquantified, are an adverse impact of the Proposed Action on individuals. If the numbers of entrained individuals are substantial, then there may be an adverse impact to sucker population at Clear Lake Reservoir.

7.2.2. Effects to Gerber Reservoir Individuals and Populations

The Proposed Action is for Gerber Reservoir to operate it so that the surface elevation is at or above 4,798.1 feet above msl water annually on September 30. In similar fashion as water availability projections are made for Clear Lake Reservoir, about April 1 of each year, the current April through September inflow forecast, current Reservoir elevation, estimated leakage and evaporative losses, and an end of September minimum elevation of 4,798.1 feet are used to determine available irrigation water from Gerber Reservoir. The amount of irrigation water available is updated with new inflow forecasts and surface elevations as the irrigation season progresses. In-season updates inform the decisions to curtail or terminate irrigation deliveries to avoid going below the minimum surface elevation.

7.2.2.1. Effects to Gerber Reservoir Adult Spawning and Migration

Access to Gerber Reservoir tributaries, where shortnose sucker spawning occurs, requires a minimum surface elevation of about 4,805.0 feet during February through May (USFWS 2008a). During very dry years both Barnes Valley and Ben Hall creeks typically have low spring flows that may not provide adequate upstream passage for spawning adults regardless of lake elevations (Reclamation 2001a). Although surface elevations at the end of September have been observed below the proposed minimum elevation of 4,798.1 feet in 5 years from the Period of Record at Gerber Reservoir (1931, 1960, 1961, 1991, and 1992), surface elevations of at least 4,805.0 feet were reached the following spring by the end of March (Table 6-4; Appendix 6B). Based on review of surface elevations from the Period of Record for Gerber Reservoir, the Proposed Action, which maintains the current lake management of a minimum surface elevation at or above 4,798.1 feet at the end of September, will not impact shortnose sucker access to spawning habitat during the following spring months based on the hydrology of Gerber Reservoir.

7.2.2.2. Effects to Gerber Reservoir Habitat for Larvae and Young-of-the-Year Juveniles

Sucker habitat requirements are less understood for endangered sucker populations in the Lost River Basin. Assumptions regarding sucker habitat use at each life history stage are based on observations from UKL and are described in Clear Lake Reservoir sections above. The description of lake surface area and depth as habitat for older juvenile and adult suckers at Gerber Reservoir is applicable to larvae and both YOY and older juveniles (*See* Section 7.2.2.3., Effects to Gerber Reservoir Habitat for Older Juvenile and Adult Suckers).

7.2.2.3. Effects to Gerber Reservoir Habitat for Older Juvenile and Adult Suckers

The effects of low water elevations at Gerber Reservoir on the resident shortnose sucker population in terms of population size, age-class distribution, recruitment, or decreased body condition are not fully understood. However, available information (Barry et al. 2007a, Leeseberg et al. 2007) indicates that the Gerber Reservoir sucker population has remained viable under the current management regime (USFWS 2008a).

The Proposed Action may adversely impact individual suckers through infrequent reductions of habitat availability, particularly decreased shoreline, surface area, and water depth. During infrequent events of prolonged drought, individual suckers will likely experience reduced condition, which can lead to mortality, and populations may contract in size if substantial numbers are lost to mortality or individual reproductive health is compromised to the point that there is a reduction in recruitment.

The minimum proposed elevation for the end of September is no less than 4,798.1 feet and will likely provide adequate water depths for protection against winter-kill of the shortnose suckers (USFWS 2008a).

7.2.2.4. Effects to Gerber Reservoir Water Quality as Habitat

Water quality monitoring over a wide range of lake levels and years has documented water quality conditions that are periodically stressful to suckers but were generally adequate for sucker survival (Reclamation 2001a, 2007, Piaskowski and Buettner 2003, Phillips and Ross 2012 draft). Periodic stratification during summer and fall in the deepest portion of Gerber Reservoir can result in DO concentrations that are stressful to suckers (Piaskowski and Buettner 2003). Stratification at Gerber Reservoir has been observed persisting for less than a month, over a small portion of the Reservoir near the dam (Piaskowski and Buettner 2003), and is likely more the result of meteorological conditions than lake surface elevations.

The Proposed Action results in periodic low surface elevations at Gerber Reservoir during late summer and fall (Table 6-4). In Gerber Reservoir, low lake levels may result in degraded water quality including higher pH values and lower DO concentration. The Proposed Action may infrequently impact shortnose suckers in Gerber Reservoir by contributing to degraded water quality conditions through low surface elevations. The adverse impacts can be to both individuals and populations through loss of individual body condition or loss of individuals through mortality.

7.2.2.5. Effects of Entrainment Losses at Gerber Reservoir

Past efforts to quantify entrainment or salvage stranded suckers in Miller Creek downstream of Gerber Reservoir suggest approximately 200 to 250 YOY and older juvenile suckers are annually entrained (*See* Part 6). Based on quantities of water delivered in the past decade and the Proposed Action, it is assumed up to 250 YOY and older juvenile suckers will be entrained under the Proposed Action. This is an adverse impact to suckers entrained due to the ephemeral nature of Miller Creek during fall and winter. The opening of Gerber Dam frost valves at the end of irrigation season allows for a Miller Creek flow of approximately 5 cfs, in addition to accretions from seep and storm run-off. This amount of flow may not allow for stream pool connectivity but is believed to prevent mortalities among fish stranded in stream pools at the end of irrigation season. It is unknown if the number of entrained individuals adversely impacts shortnose sucker populations in Gerber Reservoir as a result of the Proposed Action; however, available information (Barry et al. 2007a, Leeseberg et al. 2007) indicates that the Gerber Reservoir sucker population has remained viable under the current management regime (USFWS 2008a).

7.2.3. Effects to Tule Lake Individuals

7.2.3.1. Effects to Tule Lake Adult Spawning and Migration

From April 1 to September 30, a minimum surface elevation of 4,034.6 feet was determined for Tule Lake Sump 1A in part to provide access to spawning areas below Anderson Rose Diversion Dam (USFWS 2002, 2008a) and in part to provide for delivery of irrigation water to lands east and south of Sump 1A. The Proposed Action, which continues to manage Tule Lake Sump 1A for a surface elevation of 4,034.6 feet from April through September, will not impact sucker access to spawning in the lower Lost River due to lake elevation when conditions, such as flows, encourage spawning in the Lost River.

7.2.3.2. Effects to Tule Lake Habitat for Larvae and Young-of-the-Year Juveniles

The wetland area of Tule Lake Sump 1A near the Lost River mouth likely provides sufficient habitat for larvae and young juveniles assuming that larval and YOY juvenile suckers in Tule Lake utilize near-shore and vegetated habitats similar to suckers in UKL. Larval suckers in UKL appear to depend on shallow, near-shore areas (Simon et al. 2000, 2009), particularly those areas vegetated with emergent wetland plants in UKL (Buettner and Scoppettone 1990, Klamath Tribes 1995, Simon et al. 1995, 1996, Markle and Simon 1993, 1994, Cooperman and Markle 2000, Dunsmoor et al. 2000, Reiser et al. 2001, Cooperman 2002, Markle and Dunsmoor 2007). Water levels in Tule Lake sumps have been managed according to criteria set in previous BOs (USFWS 2002). From April 1 to September 30, a minimum elevation of 4,034.6 feet was set in part to provide for dispersal of larvae and to provide rearing habitat in Tule Lake (USFWS 2008a). These water level operations appear to provide adequate habitat for larval and juvenile Lost River and shortnose sucker life stages (USFWS 2008a). The Proposed Action is not anticipated to impact the amount or quality of larval sucker habitat in Tule Lake Sump 1A.

7.2.3.3. Effects to Tule Lake Habitat for Older Juveniles and Adults

Water depth as cover for older juvenile and adult suckers is limited due to the shallow bathymetry of the Tule Lake sumps. Surface elevations in Tule Lake Sump 1A of 4,034.6 feet from April through September and 4,034.0 feet from October through March appear to provide adequate habitat with areas of water depth greater than 3feet to older juveniles and adults; however, there is continued concern about the shallow bathymetry of the sumps and the possibility of continued sedimentation (USFWS 2008a). The Proposed Action may adversely impact older juvenile and adult suckers in Tule Lake Sump 1A due to limiting habitat, largely water depth.

7.2.3.4. Effects to Tule Lake Water Quality as Habitat

Because of the shallow depths in Tule Lake sumps and relatively small change in water levels, the impact of water level management on water quality is probably small (USFWS 2008a). Poor water quality in Tule Lake can reduce the body condition and survivorship of individual suckers. The impact of the Proposed Action on water quality within Sump 1A is difficult to assess due the naturally nutrient-rich inflows from Basin surface water to Tule Lake. The Proposed Action likely contributes to the adverse impact to the water quality in the sumps in combination with the nutrient concentrations of inflows and internal nutrient cycling within the sump shallows. The Proposed Action adversely impacts suckers in Tule Lake through contributing to adverse water quality conditions.

7.2.3.5. Effects of Entrainment Losses at Tule Lake

There are five federally-owned, unscreened diversion points from Tule Lake sumps (R Pump, R Canal, Q Canal, D Pumping Plant, and N-12 Lateral Canal; Loyd and Bolduc 2004). These diversions are an unquantified risk to suckers in Tule Lake through entrainment. Although unquantified, the risk to suckers is likely low due to the low numbers of early life history stages present (Hodge and Buettner 2008, 2009), and due to the assumptions that adult suckers tend to avoid diverted flows and are better able to avoid diverted flows than earlier life history stages. However, entrainment losses are an adverse impact of the Proposed Action.

7.2.3.6 Effects of Possible Sucker Relocation from Tule Lake Sumps

During dry winter conditions with significant reductions in available surface water, elevations in the Tule Lake sumps may recede to low levels that may adversely impact suckers in the sumps. If Reclamation and the USFWS, through discussions during a dry winter, deem it necessary to relocate suckers from Tule Lake, Reclamation, USFWS, and the Refuges will coordinate on a proposal to relocate suckers from the Tule Lake sumps before seasonally stressful water conditions develop. In the rare instance that dry winter conditions would precipitate sucker relocation from Tule Lake sumps, it is anticipated that approximately 500 adult suckers could be captured and relocated in a two week effort (Courter et al. 2010). With advance planning and additional effort it is estimated that up to 1000 adult suckers could be captured and relocated. The observed short-term (i.e., within 48 hours after release) mortality from capture, transport, and release of adult suckers was less than five percent (Courter et al. 2010). If the mortality associated with the capture and relocation of 1,000 adult suckers from Tule Lake is double the previous short-term observation, then it is anticipated that 100 adult suckers will die as a result of stresses from capture and relocation.

In the unlikely event that a relocation effort is needed at the Tule Lake sumps, this action will result in an adverse impact to suckers through the stress of up to 1,000 individuals and the mortality of up to 100 individual from the action of capture, transport, and release.

7.2.4. Effects to Lost River Proper Individuals

7.2.4.1. Effects to Lost River Proper Adult Spawning and Migration

Much of the fish habitat, including spawning habitats, in both the upper and lower Lost River is fragmented by the presence of dams and the irregular flows effecting adult sucker passage between habitats. The Proposed Action which seasonally controls flows in the Lost River will result in adverse impacts by limiting adult sucker access to spawning habitat in the Lost River and its tributaries, which reduces sucker reproduction in the Lost River.

7.2.4.2. Effects to Lost River Proper Habitat for Larvae and Young-of-the-Year Juveniles

As a result of the Proposed Action to operate the Lost River for water delivery during irrigation season and flood control during fall and winter, individual YOY juveniles are adversely impacted through a reduction of habitat availability. During irrigation season, habitats in the Lost River are suitable for early sucker life history stages. Fall and winter habitats become fragmented by October at the end of irrigation season as flows in the Lost River recede. However, periodic weather and low elevation runoff events increase Lost River flows during fall and winter, temporarily allowing connectivity between impounded areas and deep pools. The reduction of flows in both the upper and lower Lost River may lead to stress from crowding, lack of food and cover, increased predation and disease, and increased risk of poor water quality (Reclamation 2007). Past and current operations of Lost River facilities provide adequate habitat to maintain small groups of shortnose suckers in the Lost River; however, flow diversions in the Lost River have negative impacts to individual suckers in the Lost River when flows are significantly reduced after the irrigation season (USFWS 2008a).

7.2.4.3. Effects to Lost River Proper Habitat for Older Juveniles and Adults

Based on Shively et al. (2000b), older juvenile and adult endangered suckers reside in impounded areas or deep pools in the Lost River except during the spring spawning period when they migrate (Reclamation 2001a, USFWS 2002, Sutton and Morris 2005). Most of the adult sucker observations in the Lost River are from the upper Lost River above Bonanza, Oregon (Shively et al. 2000b). There are very few older juvenile or adult suckers residing in the lower Lost River, below Lost River Diversion Dam (Reclamation 2001a, USFWS 2002).

Adult sucker habitat is fragmented within the Lost River similar to habitat for earlier life history stages. As with earlier life history stages, seasonal flow diversions under the Proposed Action, particularly flow reduction at the end of irrigation season in the Lost River, have negative impacts to individual suckers in the Lost River. Increased crowding of adult suckers into remaining available habitat at either the impoundments or deep pools, following reduced flows at the end of the irrigation season adversely impact individual adult suckers in the Lost River. Inflows from groundwater and low elevation runoff during weather events in the fall and winter periodically lessen the impacts of reduced habitat during the fall and winter months by reconnecting isolated areas of habitat (i.e., reservoirs and deep pools).

7.2.4.4. Effects to Lost River Proper Water Quality as Habitat

Run-off and drain water is likely to contain nutrients, organics, and sediment, and have adverse effects to the Lost River and shortnose sucker habitat by deteriorating water quality (USFWS 2008a). The effects would most likely be due to low DO concentration from decay of algae and macrophytes, and from organics that decompose and consume oxygen (USFWS 2008a). Adverse effects to the Lost River and shortnose suckers from Project runoff and drainage are most likely to occur in the middle and lower Lost River system because these habitats are downstream from large areas of agriculture including most of the Project (USFWS 2008a). It is difficult to partition and assess water quality impacts related to nutrients between those carried on return flows and those carried on waters from Clear Lake Reservoir, Gerber Reservoir, and accretions in the Lost River. However, periods of adverse water quality, regardless of the source in the Lost River, adversely impact individual suckers that are present. The Proposed Action will adversely impact water quality in the Lost River through an incremental contribution of nutrients transported on return flows.

7.2.4.5. Effects of Entrainment Losses at Lost River Proper

Unscreened diversions in the Lost River pose an unquantified adverse impact to individual suckers at each life history stage. Both lethal and non-lethal impacts related to entrainment are anticipated as a result of the Proposed Action within the Lost River.

7.3. Effects of Operation and Maintenance Activities Associated with Klamath Project Operations

Gates at Gerber Dam, Clear Lake Dam, Link River Dam and fish ladder, Lost River Diversion Dam, the LRDC, and A Canal are exercised twice each year before and after irrigation season, March through November. The exercising of irrigation gates will likely have short-term, temporary impacts to juvenile and adult suckers in the immediate vicinity of the dam during exercise operations. It is anticipated that most individuals will move away from the exercised gate due to the sudden change in the surrounding environment; however, an unknown quantity of individuals may be entrained through the gates during exercises. The component of the Proposed Action that includes O&M of Project facilities related to dam and diversion gates is anticipated to possibly have adverse impacts to suckers largely through harassment and entrainment.

7.3.1. Effects of Clear Lake Dam Maintenance

Typically, once each year before the start of irrigation season in March or April, gates at Clear Lake Dam are opened to flush sediment that accumulates in front of the dam gates. This activity creates a maximum release of 200 cfs and lasts for approximately 30 minutes. Periodically, the fish screens at Clear Lake Dam need to be manually cleaned during the irrigation season dependent on lake elevations and sediment. During the cleaning, one of the two fish screen sets is always in place to prevent entrainment of juvenile and adult fishes.

Sudden opening of the Clear Lake Dam gate may entrain individual juvenile and adult suckers, but it is anticipated that a number of fish will move away from the disturbance created by the open gate. The downstream transport of sediment into the Lost River during gate openings is short-term and temporary in nature with most of the sediment settling in pools in the upper Lost River between Clear Lake Reservoir and Malone Reservoir. Manual cleaning of the fish screens at Clear Lake Dam are anticipated to have insignificant impacts to suckers.

7.3.2. Effects of A Canal Headworks Maintenance

Gates at A Canal are only operated and exercised with the fish screens in place. Should an occasion occur where the fish screens become inoperable during irrigation season, it is likely that all flows will need to be truncated in order to replace or repair the fish screen. These activities at A Canal are not anticipated to impact suckers. At the end of irrigation season, the A Canal gates are closed and the forebay between the trash rack and head gates is slowly dewatered. Annual fish salvage occurs within the dewatered forebay during late October or early November. During the fish salvage, up to 250 YOY and older juvenile suckers were previously captured through seining and electrofishing (Kyger and Wilkens 2011b, 2012). Continued monitoring (and fish salvage when fish are observed) in the A Canal forebay during the week following initial salvage indicates very few fish remain in the forebay (Kyger and Wilkens 2011b, 2012). Salvaged suckers are measured, tagged, and returned to UKL. Adverse impacts to several hundred juvenile suckers are anticipated during this salvage process through stress. Observed mortality of salvaged suckers has been low; however, stranding prior to, or in absence of, fish salvage results in mortality (Kyger and Wilkens 2012).

7.3.3. Effects of Lost River Diversion Channel Maintenance

Inspection of the gates and canal banks within the LRDC takes place once every six years. Inspections require a drawdown of water within the channel and can occur any time of the year. A drawdown of the channel would be coordinated with fish biologists to ensure adequate water is left to improve fish survival in pools during short term periods of low water levels. During drawdown, pools will be monitored to prevent stress to fish stranded until flows return. Adverse impacts in the form of stress are anticipate at each sucker suckers life history stage, but will likely be short term and temporary in nature. When practical, drawdown of the LRDC will occur during late fall through early winter when fewer suckers may be present in the channel to reduce impacts to suckers.

7.3.4. Effects of Link River Dam Fish Ladder Maintenance

Gates to the Link River Dam fish ladder are exercised twice each year: once between January and April, and again between October and December. While the gates are exercised, the fish ladder is dewatered and the entire structure is inspected. Fish are salvaged from the ladder while dewatered and returned to either the Link River or UKL. These activities have a short-term, temporary impact to suckers in and adjacent to the ladder.

7.3.5. Effects of Canals, Laterals, and Drains Maintenance

Nearly all canals, laterals, and drains are annually dewatered at the end of irrigation season, as late as November for Project canals in California. Canals remain dewatered until the following spring (as early as late March) except for localized precipitation runoff. Reclamation has proposed a conservation measure for the salvaging suckers at specific locations as described in Section 4.5.1. in an effort to minimize effects associated with dewatering canals. Some maintenance of canals occurs during irrigation season such as removal of plant material from trash racks at water control structures. These temporary activities are not anticipated to impact suckers.

Most canal, lateral, and drain maintenance occurs while canals are dewatered and includes removal of sediment, vegetation, concrete repair, and culvert/pipe replacement. Gates, valves, and equipment associated with canals and facilities are exercised before and after the irrigation season (i.e., before April and after October). In the past, these activities have typically occurred after dewatering of the canals and after fish salvage of Project canals. Some activities such as culvert and pipe replacement may temporarily increase sediment transportation. Based on the presence and abundance of suckers in Project canals (Kyger and Wilkens 2011b, 2012), adverse impacts to suckers are anticipated in regard to seasonal canal dewatering and routine maintenance on canal infrastructure. Most impacts such as increase in sedimentation are temporary and result in stress for fish. Other impacts may include mortality through long-term stranding, such as may occur when canals are dewatered and pools become disconnected. Fish salvage of remaining pools following dewatering has prevented mortality losses of approximately 100 to 1000 juvenile suckers each year since 2008 (Kyger and Wilkens 2012).

7.3.6. Effects of Weed and Pest Abatement

Roads and dikes are mowed as necessary from March through October to control plant growth. Some weed and pest control along dikes and on Reclamation property require the application of herbicides and pesticides. Reclamation applies chemicals annually from February through October at select areas in accordance with our Pesticide Use Permit and according to the manufacturers' labels. The effects of these activities have been evaluated in previous section 7 consultations and incidental take coverage was provided in the USFWS's BOs 1-7-95-F-26 and 1-10-07-F-0056 dated February 9, 1995 and May 31, 2007, respectively. For additional information on pesticide and herbicide *See* Section 6.2.1.4. Effects are consistent with and remain covered under previous BOs.

7.3.7. Effects of Right-of-way and Access Maintenance

Right-of-way and access maintenance may temporarily cause sedimentation into adjacent waterways, principally canals. Gravel is periodically added to road beds or boat ramps (i.e., Clear Lake Reservoir). Road beds are periodically re-graded. The impact of sedimentation is likely to have a temporary impact to individual suckers that may be present.

7.3.8. Effects of Water Measurement

Water measurement devices, such as gauges, require annual maintenance to flush sediments from stilling wells, replace faulty gauges, or modification/replacement of supporting structures. Flushing the stilling wells occurs during irrigation season (April through October) and may temporarily increase sedimentation downstream of the gauge. The amount of sedimentation is often very small and the sediment settles a short distance downstream. In some instances, when a large amount of sediment is present, the sediment is removed from the stilling well and deposited at nearby upland locations. Other activities such as replacement or repositioning of a measurement device and associated infrastructure may require the construction of a small, coffer dam or be conducted during low flow periods. Measurement device sites are anticipated needing replacement or repair once every 5 to 10 years. If construction of a coffer dam is required, then fish will be salvaged from behind the dam prior to replacement of infrastructure. Replacement or repositioning of a site will have short term adverse impacts to suckers. Suckers will likely avoid the disturbance during activity but may need to be captured and moved to a location further from the impacted area. Replacement of equipment and flushing of stilling wells will have temporary impact to suckers present in the immediate area of the gauge. Most of these impacts are anticipated as non-lethal stress during site activity.

7.4. Effects to Proposed Critical Habitat

In December 2011, USFWS proposed the designation of critical habitat for Lost River and shortnose suckers (76 FR 76337, USFWS 2011a). Critical habitat designation is defined in Section 3 of the ESA as: (1) specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Act, on which are found physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.

In defining the physical and biological features and habitat characteristics required for Lost River and shortnose sucker conservation, USFWS identified physical and biological features essential to the conservation of Lost River sucker and shortnose sucker in areas occupied at the time of listing, focusing on the features' primary constituent elements. Primary constituent elements are the specific elements of physical and biological features that are essential to the conservation of the species (76 FR 76337, USFWS 2011a). Based on our knowledge of the physical or biological features and habitat characteristics required to sustain the species' life-history processes at the time of the proposed critical habitat, the primary constituent elements specific to self-sustaining Lost River sucker and shortnose sucker populations are: water, spawning and rearing habitat, and food (76 FR 76337, USFWS 2011a). These three primary constituent elements are described as follows (76 FR 76337, USFWS 2011a):

1. *Water*. Areas with sufficient water quantity and depth within Lakes, reservoirs, streams, marshes, springs, groundwater sources, and refugia habitats with minimal physical, biological, or chemical impediments to connectivity. Water should exhibit depths ranging from less than 1.0m (3.28 feet) up to 4.5m (14.8 feet) to accommodate each life stage. The water quality characteristics should include water temperatures of less than 28.0°C (82.4°F); pH less than 9.75; DO levels greater than 4.0 mg per L; algal toxins (less than 1.0 microgram (µg) per L); and un-ionized ammonia (less than 0.5 µg per L). Elements also include natural flow regimes that provide flows during the appropriate time of year or, if flows are controlled, minimal flow departure from a natural hydrograph.

2. *Spawning and rearing habitat.* Streams and shoreline springs with gravel and cobble substrate at depths typically less than 1.3m (4.3 feet) with adequate stream velocity to allow spawning to occur. Areas identified in PCE1 (*sic* primary constituent element 1) containing emergent vegetation adjacent to open water that provides habitat for rearing. This facilitates growth and survival of suckers, as well as protection from predation and protection from currents and turbulence.

3. *Food.* Areas that contain an abundant forage base, including a broad array of chironomidae, crustacea, and other aquatic macroinvertebrates.

7.4.1. Effects to Critical Habitats in UKL and Tributaries

7.4.1.1. Effects to Water

A surface elevation of 4,138.5 feet provides approximately 13,000 acres (about 46 percent) of the northern portion of UKL at a depth of 2m or greater. In dry conditions (at the 95 percent exceedance levels), the Proposed Action provides UKL surface elevations at or above 4,138.2 feet by the end of each July, August, and September. Surface elevations below 4,138.0 feet at the end of September are likely to adversely impact older juvenile and adult suckers by reducing the amount of open water habitat available in the depth range utilized by suckers to about 20 percent of available habitat. The Proposed Action during inflow conditions drier than those at the 95 percent exceedance level results in end of September surface elevations between 4,137.8 feet. It is anticipated that UKL surface elevations are less critical to suckers from November through March because suckers redistribute throughout the lake after water quality in the lake improves and lake levels increase through the winter (Banish et al. 2007, 2009, USFWS 2008a).

The Proposed Action is not anticipated to influence water quality in UKL. Water quality conditions in UKL are mostly attributed to nutrient loading (Buchanan et al. 2011). USGS has conducted extensive analyses of existing water quality data from UKL. Wood et al. (1996) and USGS, concluded that there was no evidence for a relation between any of the water quality variables considered (chlorophyll, DO, pH, and total phosphorus) and lake depth on the basis of seasonal distribution of data or a summary seasonal statistic. The analysis found that low DO, high pH, high phosphorus concentrations, and heavy blooms of AFA were observed each year regardless of lake depth. The USGS repeated this analysis with a 17-year dataset (1990 through 2006) and the inclusion of eleven more years of data did not demonstrate a discernible relationship between lake depth and water quality (Morace 2007).

7.4.1.2. Effects to Spawning and Rearing Habitat

The Proposed Action continues past elevation management of high surface elevations during adult spawning from March through May. Surface elevations as a result of the Proposed Action will not impact habitat in the tributaries and is likely to adversely impact the amount of shoreline spawning area available in some years. Surface elevations by the end of April are above 4,142.0 feet in all model years but one with implementation of the Proposed Action. Only in model year 1992 does the UKL surface elevations fail to reach 4,142.0 feet by the end of April at the shoreline spawning areas). During model year 1992 available spawning habitat at the shoreline areas is reduced, but still greater than 50 percent of the available habitat.

Under the proposed water management action, lake surface elevations are anticipated at or above 4,141.4 feet by the end of June and at or above 4,140.1 feet by the end of July in all but the driest years (at the 95 percent exceedance levels; Table 7-4). A lake surface elevation of 4,141 feet provides approximately 70 percent of the emergent vegetation habitat in UKL. Even during dry conditions, such as the 95 percent exceedance level, it is anticipated that greater than 50 percent of emergent vegetation will be inundated with at least one foot of water through the end of June. During low inflow years (drier than 95 percent exceedance levels) declining amounts of emergent vegetation are still available through June and July. This indicates that under the worst water conditions from the Period of Record, inundated emergent vegetation would have still been available to larval suckers into early July under the Proposed Action.

Lake surface elevations by the end of September, nearing the end of the period when YOY juveniles are most prevalent in near-shore areas of UKL, are anticipated to be above 4,137.8 feet, and as high as 4,140.6 feet if managed according to the Proposed Action. Circumstances of low inflow conditions in the Period of Record indicate that the Proposed Action results in end of September surface elevations below 4,138.0 feet in only one year during the 31-year Period of Record used to evaluate the Proposed Action. Below 4,138.0 feet, near-shore habitat diversity becomes diminished.

Lake surface elevations under the Proposed Action remain near 4,138.9 feet by the end of August (at 95 percent exceedance) in all but the driest of years and at or above 4,137.8 feet by the end of September in all years. While emergent vegetation is diminished as a near-shore habitat below elevations of about 4,140.0 feet based on previous surveys, this habitat is still available to YOY juvenile suckers in most years until late summer. During dry conditions, there is likely to be a loss of diversity of near-shore substrates during late summer and early fall.

7.4.1.3. Food

Entrainment of zooplankton and macro-invertebrates may occur with delivery of water from UKL. However, the Proposed Action is not anticipated to appreciably reduce food availability in UKL due to the relatively high abundance of zooplankton and benthic macro-invertebrates in UKL (Hazel 1969). Reduced surface elevations in UKL may concentrate suckers into limited areas where food resources may become limited through competition.

7.4.2. Effects to Critical Habitat in Link to Keno Impoundment Reach of Klamath River

7.4.2.1. Water

Under the Proposed Action, flows for agriculture and downstream environmental needs will be released from Link River Dam. Surface elevations in the Link to Keno Impoundment Reach of the Klamath River are expected to be similar to recent and historic elevations. The Proposed Action is not anticipated to impact water depth in the Link to Keno Impoundment Reach.

The quality of water entering, within, and leaving the Link to Keno Impoundment Reach is largely due to poor quality water entering from UKL containing large amounts of organic matter with an associated high BOD (Doyle and Lynch 2005, Deas and Vaughn 2006). Water from UKL, and the organic matter and nutrients carried with the water, may incrementally reduce water quality in the Link to Keno Impoundment Reach, particularly during warm weather periods.

7.4.2.2. Spawning and Rearing Habitat

Spawning activity in the lower Link River, upstream of the West Side hydropower facility, was observed during May 2007 (Smith and Tinniswood 2007). No other spawning habitat exists between the Link River and Keno dams (Buchanan et al. 2011). The proposed water operation of UKL with Link River Dam releases for downstream needs are anticipated to not impact spawning habitat in the Link River.

The ongoing management to operate for stable surface elevations in the Link to Keno Impoundment Reach of the Klamath River impacts development of additional wetland habitats and degrades the quality of existing wetlands through controlled water depth (USFWS 2007c). However, stable surface elevations do provide sucker access to the established wetland habitats for rearing during sucker early life history stages.

7.4.2.3. Food

Abundance of benthic macro-invertebrates is high in the Lost River (Shively et al. 2000b) and UKL (Hazel 1969). There is a lack of information on prey species abundance in Gerber Reservoir; however, prey species are assumed to be relatively high. Prolonged drought may concentrate fish into remaining habitat and reduce food availability through competition in Gerber Reservoir. Although prey species may be entrained on water delivery from Gerber Reservoir, the Proposed Action is not anticipated to appreciably reduce food availability based on the assumption that prey species are abundant.

7.4.3. Effects to Critical Habitat in Clear Lake Reservoir and Tributaries

7.4.3.1. Water

The Proposed Action may affect fish habitat in the lake at Clear Lake Reservoir due to low surface elevations when both depth and surface area of habitat contract. At low lake levels, the size of Clear Lake Reservoir decreases substantially and is reduced to a few percent of capacity. Based on bathymetry of Clear Lake Reservoir, the east lobe is nearly dry at an elevation of about 4,520.0 feet. At lake elevations less than 4,520.0 feet, the remaining sucker habitat in Clear Lake Reservoir is most likely the west lobe and the western portion of the channel between the two lobes. Of the area in the western lobe at a surface elevation of about 4,520.0 feet, the majority appears to be greater than four feet (greater than1.2m). Given the natural hydrology at Clear Lake Reservoir, surface elevations will need to be carefully monitored to ensure that they do not drop below minimum requirements, especially during multi-year droughts. If the lake level at the beginning of a drought is low, lake levels the next year may be even lower, and the lake could theoretically go dry in consecutive drought years (USFWS 2008a). The minimum proposed Clear Lake Reservoir elevations will likely provide adequate protection from drought in most years. Extended drought may result in a significant reduction in lake area and depth.

At Clear Lake Reservoir, lower water levels may result in degraded water quality, particularly higher water temperatures and lower DO. Consequently, very low lake levels in Clear Lake Reservoir during consecutive drought years could adversely water quality (USFWS 2008a). However, water quality monitoring over a wide range of lake levels and years documented water quality conditions that were adequate for sucker survival (Reclamation 1994a, 2001, 2007).

7.4.3.2. Spawning and Rearing Habitat

The Proposed Action may periodically impact access to Willow Creek at Clear Lake Reservoir. Sucker access to Willow Creek appears to be a function of lake surface elevation (approximately 4,524.0 feet) and creek discharge during spring months. A minimum lake elevation of 4,520.6 feet above sea level by the end of September each year is intended to conserve lake surface area and water depth as fish habitat into the winter months and the following year, and to lessen the impacts of reduced spawning access the following spring. Extended drought may result in consecutive years of reduced surface elevations which may adversely impact access to Willow Creek.

Relatively little is known about rearing habitat requirements at Clear Lake Reservoir. Assuming that lake surface area, water depth, and shoreline are important components of rearing habitat, then the Proposed Action may affect rearing habitat in Clear Lake Reservoir at low surface elevations when habitat contracts.

7.4.3.3. Food

Abundance of benthic macro-invertebrates is high in the Lost River (Shively et al. 2000b) and UKL (Hazel 1969). There is a lack of information on prey species abundance in Clear Lake Reservoir; however, prey species are assumed to be relatively high. Prolonged drought may concentrate fish into remaining habitat and reduce food availability through competition in Clear Lake Reservoir. Although prey species may be entrained on water delivery from Clear Lake, the Proposed Action is not anticipated to appreciably reduce food availability based on the assumption that prey species are abundant.

7.4.4. Effects to Critical Habitat in Gerber Reservoir and Tributaries

7.4.4.1. Water

The Proposed Action may reduce surface area, water depth, and shoreline areas as habitat during periods of prolonged drought at Gerber Reservoir. Low lake elevations may also result in degraded water quality including higher pH values and lower DO concentration. Water quality monitoring over a wide range of lake levels and years has documented water quality conditions that are periodically stressful to suckers but were generally adequate for survival (Reclamation 2001a, 2007, Piaskowski and Buettner 2003, Phillips and Ross 2012 draft).

7.4.4.2. Spawning and Rearing Habitat

The Proposed Action is not anticipated to impact spawning habitat at Gerber Reservoir. Sucker access into Barnes Valley and Ben Hall creeks, the principal spawning tributaries for suckers in Gerber Reservoir, requires a minimum spring (February through April) elevation of about 4,805.0 feet (USFWS 2008a). Surface elevations of at least 4,805.0 feet were reached each spring by end of April in all years for the Period of Record and were reached by the end of March in all years but 1992. However, in very dry years both Barnes Valley and Ben Hall creeks typically have low spring flows that may not provide adequate upstream passage for spawning adults regardless of lake elevations (Reclamation 2001a).

The Proposed Action is anticipated to have minimal impact to rearing habitat at Gerber Reservoir. At Gerber Reservoir, larval and juvenile suckers likely utilize lake surface area, water depth, and shoreline as habitat. At 4,800 feet, the surface area of the lake decreases to about 750 surface acres. As lake surface elevation decreases so do the amounts of available habitat.

7.4.4.3. Food

It is assumed that zooplankton and benthic macro-invertebrate abundance in Gerber Reservoir is similar to elsewhere in the Upper Klamath Basin (Hazel 1969, Shively et al. 2000b). The Proposed Action is not anticipated to appreciably reduce food availability except during prolonged drought which may concentrate fish into remaining habitat and reduce food availability through competition in Gerber Reservoir.

7.5. Cumulative Effects

Cumulative effects are those impacts of future State and private actions that are reasonably certain to occur within the area of the action subject to consultation. Future federal actions will be subject to the consultation requirements established in section 7 of the ESA and therefore, are not considered cumulative to the Proposed Action.

The federal Clean Water Act requires States to develop plans with goals and pollution targets for improving water quality in water bodies that are designated as impaired because of excessive quantities of various pollutants. This is done by establishing limits known as TMDLs for pollutants that are preventing a water body from meeting its designated uses. Local, state, and federal governments and/or private entities are responsible for addressing pollution under their control by developing management strategies, implementation plans, and schedules that are designed to collectively meet TMDL allocations. ODEQ completed a TMDL analysis and report in 2002 for the Upper Klamath and Lost River subbasins within the Klamath Basin. The completion of the mainstem Klamath River TMDL in California and Oregon is currently in development. Implementation of the resultant water quality management plans will aid in improving water quality in UKL and its tributaries as well as the mainstem Klamath River in habitats occupied by listed suckers, which is beneficial to listed suckers and their habitats.

7.6. Summary and Determination

7.6.1. Upper Klamath Lake and Tributaries Summary

The Proposed Action will adversely impact the amounts of available shoreline spawning habitat, emergent vegetation, and area of preferred lake depth in the northern portion of UKL. It is anticipated that the amount of habitat for success of each sucker life history stage will be adequate in all years except during years of low inflow to UKL when habitat amounts will be reduced. Reduced habitat quantity and quality will impact individual suckers at each life history stage. A large number of individual impacts could result in population level impacts, such as repeat skipped spawning at the shoreline and reduced body condition or survivorship as a result of prolonged periods of limited habitat. These impacts are only anticipated during extreme or consecutive low inflow conditions to UKL (e.g., the early 1990s). It is anticipated that results of dry conditions can be managed through real-time management decisions within the Proposed Action.

The Proposed Action will also adversely impact individual suckers at each life history stage through entrainment from UKL. Large estimated numbers of larvae and YOY juvenile suckers each year exit UKL through A Canal (larvae still pass the fish screen) and the Link River Dam. Whereas, population impacts are not fully understand, large losses particularly at later life history stages can adversely impact sucker populations in UKL.

The Proposed Action is not anticipated to impact water quality in UKL nor is it anticipated to impact access by older juvenile and adult sucker to areas of improved water quality such as Fish Banks and Pelican Bay.

7.6.2. Link to Keno Impoundment Reach of Klamath River Summary

The Proposed Action will have adverse impacts to individual Lost River and shortnose suckers in the Link to Keno Impoundment Reach of the Klamath River. Unquantified numbers of suckers will become entrained from the Link to Keno Impoundment Reach through unscreened diversions such as the LRDC, Ady Canal, North Canal, and numerous smaller diversions. Past monitoring at locations associated with the LRDC and near Ady and North Canals indicated that larvae and juvenile suckers are the most common sucker life history stage that will be exposed to entrainment and numbers of entrained suckers are expected to be relatively small.

Discharges into the Link to Keno Impoundment Reach from Project may impact suckers through additions of nutrients, which incrementally degrade water quality, and potential for herbicide/pesticide exposure. Whereas the Project is a net “sink” for nutrients primarily through diverting water high in nutrients from UKL, return flows through the LRDC and the Klamath Straits Drain have nutrient concentrations higher than surface water from UKL. The high nutrient concentrations on the return flows incrementally contribute to deteriorated water quality conditions in the Link to Keno Impoundment Reach; however, the full impact of return flows on water quality in the Link to Keno Impoundment Reach are confounded by the highly eutrophic outflow of UKL via the Link River. Pesticide and herbicide discharges have not been directly measured in the Link to Keno Impoundment Reach and information from Tule Lake Sump 1A indicates few pesticides are likely present; however, those that are present likely pose a risk to suckers in the Link to Keno Impoundment Reach of the Klamath River. Degraded water quality and potentially harmful chemical concentrations impact each sucker life history stage.

The Proposed Action is not anticipated to impact sucker physical habitat of surface area and depth in the Link to Keno Impoundment Reach of the Klamath River.

7.6.3. Clear Lake Summary

The Proposed Action at Clear Lake Reservoir will affect individual suckers through entrainment of larvae and small YOY juvenile suckers. Entrainment of older juvenile and adult suckers is prevented by the fish screen at Clear Lake Dam. Relatively large evaporative and seepage losses at Clear Lake Reservoir make evaluating the impact of the Proposed Action difficult to assess. However, the Proposed Action will temporarily and periodically limit habitat during periods of low surface elevations, particularly during prolonged periods of low inflow to Clear Lake Reservoir. Habitat for each sucker life history stage becomes limited when surface area contracts and water depth decreases at low surface elevations. During low surface elevations and low inflow periods, spawning access to Willow Creek appears impeded. The Proposed Action is not anticipated to substantially impact water quality at Clear Lake Reservoir. Combined impacts may have population level impacts to both Lost River and shortnose suckers at Clear Lake Reservoir if large numbers of individuals are impacted and during prolonged, multiple-year drought. A minimum lake elevation of 4,520.6 feet above sea level by the end of September each year is intended to conserve lake surface area and depth as fish habitat into the winter months and the following year, and to lessen the impacts from temporary, but periodic, spawning access limitations the following spring. A minimum surface elevation of 4,520.6 feet appears protective of Lost River and shortnose sucker populations at Clear Lake Reservoir (Reclamation 2007, USFWS 2003, 2008a).

7.6.4. Gerber Reservoir Summary

The Proposed Action at Gerber Reservoir will affect approximately 250 individual YOY and older juvenile suckers through entrainment. Although there is limited information, entrainment from Gerber Reservoir may also impact individual larval and adult suckers. The Proposed Action will temporarily and periodically limit habitat during periods of low surface elevations, particularly during prolonged periods of low inflow to Gerber Reservoir. Habitat for each sucker life history stage becomes limited when surface area contracts and water depth decreases at low surface elevations. The Proposed Action for an end of September elevation of no less than 4,798.1 feet appears to provide adequate habitat quantities for and water depths that are protective of shortnose suckers. The Proposed Action is not anticipated to impact spawning access to tributaries or water quality at Gerber Reservoir. Combined impacts may have population level impacts to shortnose suckers at Gerber Reservoir if large numbers of individuals are impacted and during prolonged, multiple-year drought.

7.6.5. Lost River Summary

Fertilizer use within the Project will reduce water quality incrementally in the Lost River above the naturally eutrophic surface waters of the Upper Klamath Basin. Although this could have adverse effects on the Lost River and shortnose suckers, there is insufficient information on possible effects to conclude that water quality reductions as a result of the Proposed Action will result in harm to suckers. Herbicide and pesticide use within the Project have seldom been detected at levels harmful to fish; however, these chemicals pose a risk that may impact both Lost River and shortnose suckers at each life history stage. Unscreened diversions from the Lost River and the seasonal fluctuation of flows adversely impact suckers, particularly at early life history stages through entrainment and fragmentation of habitat.

7.6.6. Tule Lake Summary

Surface elevation management may affect individual suckers in Tule Lake through a reduction in adult habitat, and possibly water quality; however, surface elevations in the Proposed Action are anticipated to preserve adequate depth in summer and winter to reduce the risk to individual suckers associated with low surface elevations at the Tule Lake sumps. Unscreened diversions in Tule Lake may negatively impact individual suckers through entrainment. Entrainment impacts are not likely to occur at vulnerable, early sucker life history stages due to the low numbers of larval and juvenile suckers present in Tule Lake. Entrainment could impact older juvenile and adult suckers at Tule Lake; however, these later life history stages are better adept at avoiding entrainment than early life history stages (i.e., smaller fish) and entrainment impacts are expected to be minimal on Tule Lake suckers. If dry winter conditions reduce surface water and Tule Lake sumps are predicted to be unsuitably low for suckers, then a relocation of suckers may be needed. A relocation of suckers from Tule Lake will adversely impact individual suckers through capture and transportation stress and mortality.

7.6.7. Critical Habitat Summary

Nutrient concentrations from chemical use within the Project may incrementally worsen water quality conditions in the naturally eutrophic waters at some locations in the Upper Klamath Basin as a result of the Proposed Action. Return flows with increased nutrient concentrations may impact proposed critical habitat in the Link to Keno Impoundment Reach of the Klamath River. The Proposed Action is not anticipated to influence water quality at UKL, Clear Lake Reservoir, and Gerber Reservoir.

The Proposed Action is not anticipated to influence access to spawning habitats. Periodic, though infrequent and temporary, low surface elevations as result of low inflows may impact proposed critical habitat through limiting sucker access to spawning habitat at shoreline spawning areas in UKL, tributaries to Clear Lake Reservoir, and tributaries to Gerber Reservoir. The Proposed Action is not anticipated to increase impacts to shoreline spawning areas in UKL and tributary access at Clear Lake and Gerber Reservoirs through management of surface elevations. The Proposed Action is not anticipated to impact spawning access in the Link to Keno Impoundment Reach of the Klamath River.

Periodic, though infrequent, low surface elevations as a result of low inflows and surface elevations may adversely impact rearing habitats by contracting lake surface area, area of emergent vegetation, area of preferred water depth, and area of shoreline at UKL, Clear Lake Reservoir, and Gerber Reservoir. The Proposed Action is not anticipated to increase the impacts of reduced habitat availability through surface elevation management, including real-time management of surface water. The Proposed Action is not anticipated to impact rearing habitat in the Link to Keno Impoundment Reach of the Klamath River as a result of surface elevation management. The Proposed Action is not anticipated to impact food availability at all proposed critical habitats.

7.6.8. Determination on Effects of the Proposed Action on Lost River and shortnose suckers and Proposed Critical Habitat

Based on the discussion provided within this document, Reclamation concludes that implementing the Proposed Action may affect, and is likely to adversely affect both Lost River and shortnose suckers. This means that ESA-listed suckers are likely to be exposed to the Proposed Action or its environmental consequences and will respond in a negative manner to the exposure.

The Proposed Action is not likely to adversely affect the proposed Critical Habitat for both Lost River and shortnose suckers.

7.7. Jeopardy Determination Considerations

A considerable number of studies furthering the understanding of Lost River suckers, shortnose suckers, and the Klamath Basin habitat in which they reside have been authorized, funded or otherwise carried out by state, tribal and federal agencies. Part 11, References, includes these and other reports that were reviewed and/or cited in the preparation of this BA. In addition to materials in Part 11, it is anticipated that a HCP for the Klamath Hydroelectric Project, Critical Habitat designation and a Recovery Plan for both ESA-listed sucker species will be final during this formal consultation on the Klamath Project. Information from draft versions of these documents was included in this BA; however, some information may change between this final BA and when a final BO is prepared. Information from the final versions of these plans and documents should be considered in the jeopardy determination.

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Part 8 EFFECTS OF IMPLEMENTING THE PROPOSED ACTION ON COHO SALMON

Part 8 of the BA evaluates if implementing the Proposed Action may affect Southern Oregon Northern California Coastal (SONCC) coho salmon and its designated critical habitat. Following this evaluation, Reclamation will make one of the following determinations for this ESA-listed species:

> “*No effect*" means there will be no impacts, positive or negative, to ESA-listed SONCC coho salmon or its designated critical habitat. Generally, this means no SONCC coho salmon or its designated critical habitat will be exposed to the Proposed Action and its environmental consequences.
>
> "*May affect, but not likely to adversely affect*" means that all effects are beneficial, insignificant, or discountable. Beneficial effects have contemporaneous positive effects without any adverse effects to SONCC coho salmon or its designated critical habitat. Insignificant effects relate to the size of the impact and include those effects that are undetectable, not measurable, or cannot be evaluated. Discountable effects are those extremely unlikely to occur.
>
> "*May affect, and is likely to adversely affect*" means that SONCC coho salmon or its designated critical habitats are likely to be exposed to the Proposed Action or its environmental consequences and will respond in a negative manner to the exposure.

Once a “may affect” determination is made, Reclamation must either request USFWS’ and/or NMFS’ concurrence with a “may affect, but not likely to adversely affect” finding or request initiation of formal ESA consultation if a “may affect, and is likely to adversely affect” is made. Upon completion of the formal consultation, USFWS and/or NMFS, through the issuance of a joint BO, will determine if implementing the Proposed Action causes jeopardy of the SONCC coho salmon ESU or adverse modification of its designated critical habitat.

8.1. Hydro-Modeling

Reclamation will use results generated by WRIMS to identify the Klamath River hydrograph that is likely to occur as a result of implementing the Proposed Action. WRIMS is a generalized water resources modeling system, broadly accepted by the hydrologic community, for evaluating operational alternatives of large, complex river basins. WRIMS integrates a simulation language for flexible operational criteria specification, a linear programming solver for efficient water management decisions, and graphics capabilities for ease of use. These combined capabilities provide a comprehensive and powerful modeling tool for water resource systems simulation.

8.2. Period of Record

The Hydrology Team[29] of the Agency Coordination Team recommended using October 1, 1980 to September 30, 2011 for the Period of Record from which to run the daily time step WRIMS model. October 1, 1980 to September 30, 2011 includes the recorded wettest and driest inflow into UKL along with a reasonable distribution of wet, average and dry years. With this range of data, the WRIMS model is able to evaluate a particular water operation strategy across a reasonably foreseeable range of inflows. Reclamation used WRIMS in our analysis to estimate mainstem Klamath River flows at IGD that would likely be realized through implementation of the Proposed Action during the Period of Record. Reclamation considers the resulting model outputs to reflect the range of flows reasonably expected to occur during the 10-year period of the Proposed Action (April 1, 2013 through March 31, 2023).

The historical IGD flows during the Period of Record represent a component of the past and current Baseline. Thus, these historical IGD flows include impacts from past Klamath Project operations and current Project operations consistent with the 2010 NMFS BO. Reclamation also modeled IGD flows as if the Proposed Action was implemented during the same Period of Record. As mentioned above, Reclamation considers the resulting model outputs reflective of the range of flows reasonably expected to occur during the 10-year period of the Proposed Action (April 1, 2013 – March 31, 2023).

Flows during the Period of Record are available on a daily basis. Modeling output for the Proposed Action is also available on a daily basis. Model outputs of the Proposed Action provide for a direct comparison with the flow during the Period of Record. Unfortunately, modeling output for the VBF approach is only available on a 17 time step (typically monthly or bi-monthly). Direct comparison of daily flows during the Period of Record is not directly comparable to monthly or bi-monthly model outputs.

8.3. Variable Base Flow (VBF) Approach

The latest BO for the operations of the Klamath Project contains a Reasonable and Prudent Alternative that includes bi-monthly or monthly values for flows downstream of IGD (“Table 18” in the 2010 NMFS). Reclamation currently operates under the VBF approach[30] which approximates[31] the flows identified in Table 18. The NMFS 2010 BO also contains a provision to annually increase fall and winter flow variability. The fall and winter flow variability program under the VBF approach allows for up to 18,600 AF of water to be available annually to enhance flows at IGD between September 1 and March 1.

[29] Based on the Period of Record discussion paper, dated November 04, 2011. This paper was prepared by the Agency Coordination Team (ACT)’s Hydrology Team. The ACT is made up of representatives from NMFS, the USFWS, and Reclamation for the purpose of this ESA consultation.

[30] Further information on the VBF approach may be found in a Reclamation document titled Variable Base Flow Procedure, dated February 29, 2012.

[31] Reclamation found it difficult to model a procedure for the operations of the Klamath Project that matches exactly all 228 exceedance values depicted in Table 18.

For this BA the daily time step model was used to estimate flows at IGD that would likely be realized through implementation of the Proposed Action during the Period of Record. The model used in developing the VBF approach provides annual flow output in 17 time steps. This analysis also uses the 17 time step model to estimate flows at IGD that would likely be realized through implementation of the VBF approach during the Period of Record (Appendix 8A-1). A comparison of these two model outputs can provide some understanding on the impacts of implementing the Proposed Action in comparison to the current management approach.

However, there are limitations in comparing the annual 17 time step output from the model used to develop the VBF approach with the daily time step output used to develop the Proposed Action. For example, it is not feasible to model how water managers would have implemented the fall and winter flow variability program in prior years. Implementation of the VBF's flow variability program is based on in-season information. In the analysis on the impacts to individual coho salmon, Reclamation utilized daily flow outputs. Thus, Reclamation primarily used the WRIMS daily model output during the Period of Record and compared those results with the actual daily flows during the Period of Record.

In the analysis on the impacts to the critical habitat, Reclamation will use exceedence tables in its habitat impact analysis. Exceedence tables are developed through data sorting and ranking within select time periods. The modeled outputs can be summarized by week, month, or water year (for more information on exceedence tables *See* Section 3.4.).

8.4. Ecological Effects

In this section, Reclamation will assess the likely impacts to the hydrology and water quality with the implementation of the Proposed Action. For reasons discussed in the Baseline, the Effects Analysis will focus on impacts to the hydrology and water quality downstream of IGD. In subsequent sections the likely impacts of hydrology and water quality on federally listed coho salmon and designated critical habitat will be discussed.

8.4.1. Altered Hydrology

In the following analysis, Reclamation reviewed the difference (change) in flows between the historical flows at IGD during the Period of Record (a component of the Baseline) and the modeled IGD flows if the Proposed Action was implemented during the same Period of Record. This comparison provides insight into how the change in IGD flows from the Baseline as a result of implementing the Proposed Action may impact SONCC coho salmon.

The following assessment on the differences in IGD flows[32] between implementing the Proposed Action and the historical flows during the Period of Record will be structured by the four components of a hydrograph as described in the Baseline (subsistence flows, base flows, high-flow pulses, and overbank flows).

This discussion will be followed by a discussion on the likely impacts on flow variability. The

[32] All IGD flows in this analysis are considered as measured at USGS gauge 11516530. IGD flows and IGD discharge are used inter-changeably in this analysis.

VBF approach encourages “flat-line” flows while within one of the 17 time steps. Thus, modeling output for the VBF approach is useful in assessing the likely impacts on flow variability.

8.4.1.1. Subsistence Flow

Subsistence flow is the minimum flow needed during critical drought periods to maintain tolerable water-quality conditions and to provide minimal aquatic habitat space for the survival of aquatic species (NRC 2005). The minimum flow threshold can change by season and between years. Hardy et al. (2006) considers subsistence flows to represent flows between approximately the 80 and 95 percent exceedance ranges. During the Period of Record, the average flow between the 80 and 95 percent exceedance was 949 cfs (Appendix 8A-2).

In addition, NMFS (2010) determined that a mainstem flow of 1,000 cfs is expected to provide sufficient flow to maintain connectivity to tributaries for re-distributing juvenile Coho salmon. Thus, for the reasons stated above, an evaluation of the frequency of flows less than 1,000 cfs provides some understanding of the impacts that implementing the Proposed Action may have on subsistence flows.

When the Proposed Action is applied to the Period of Record, modeling suggests that 17.4 percent (n = 1,965) of the daily average flows will be less than 1,000 cfs. This is compared to the historical flows during the Period of Record when 22.9 percent (n = 2,593) of the daily average flows were less than 1,000 cfs (Table 8-1). When compared to the Period of Record, modeling suggests that there will be a 5.5 percentage point decrease in the frequency of daily average flows that are less than 1,000 cfs with the implementation of the Proposed Action.

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the daily modeled flows that will be less than 1,000 cfs is 953 cfs. During the Period of Record, the historical average of the daily flows that were less than 1,000 cfs was 782 cfs (Table 8-1). When compared to the Period of Record, modeling suggests that there will be a 171 cfs increase in the average of the flows that are less than 1,000 cfs with the implementation of the Proposed Action.

Thus, when compared to the Period of Record, modeling suggests that there will likely be a reduction in the frequency of daily flows that are less than 1,000 cfs with the implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests that flows that are less than 1,000 cfs will be greater in magnitude, on average, with the implementation of the Proposed Action.

8.4.1.2. Base Flow

Base flow is the “normal” flow condition between storms (NRC 2005). What is considered base flow can change throughout the year. The majority of the base flows occur between 1,000 cfs and 6,000 cfs. For the purpose of this discussion, an evaluation of flows equal to or greater than 1,000 cfs but less than 6,000 cfs provides some understanding of the impacts implementing the Proposed Action will have on base flows. This range is consistent with the USGS/USFWS mapping protocol in determining side channels. Utilizing this protocol, a side channel has a temporary, un-vegetated or seasonally vegetated island (e.g., a gravel or sand bar) that is inundated by low or moderate flows (3,000 to 6,000 cfs; Hardy et al 2006).

Table 8-1. Summary of the Iron Gate Dam historical (actual) average daily flows during the Period of Record (October 1, 1980 to September 30, 2011, and for the modeled average daily flows with the implementation of the Proposed Action when applied to the same period.

Criteria	Modeled Proposed Action	Actual	Difference
Total Daily Flows			
Count Average Daily Flow (cfs) Percent of the Modeled Proposed Action	11,322 1,210 100.0%	11,322 1,340 110.7%	-0 -130 -10.7%
Less than 1,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	1965 17.4% 953	2,593 22.9% 782	-628 -5.5% 171
Greater than or equal to 1,000 cfs but less than 6,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	8,978 79% 1,845	8,257 72.9% 1,940	721 6.4% -94
Greater than or equal to 6,000 cfs but less than 12,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	355 3.1% 7,492	461 4.1% 7,715	-106 -0.9% -222
Greater than or equal to 12,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	24 0.2% 14,706	11 0.1% 14,000	13 0.1% 706

When the Proposed Action is applied to the Period of Record, modeling suggests that 79.0 percent (n = 8,978) of the daily average flows will be equal to or greater than 1,000 cfs but less than 6,000 cfs. This is compared to the historical flows during the Period of Record when 72.9 percent (n = 8,257) of the daily flows were equal to or greater than 1,000 cfs but less than 6,000 cfs. When compared to the period of Record, modeling suggests that there will be a 6.4 percentage point increase in the number of daily flows that are equal to or greater than 1,000 cfs but less than 6,000 cfs with the implementation of the Proposed Action (Table 8-1).

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the daily flows that will be equal to or greater than 1,000 cfs but less than 6,000 cfs is 1,845 cfs. During the Period of Record, the historical average of daily flows that were equal to or greater than 1,000 cfs but less than 6,000 cfs was 1,940 cfs. When compared to the Period of Record, modeling suggests that there will be a 94 cfs decrease in the average of daily flows equal to or greater than 1,000 cfs but less than 6,000 cfs with the implementation of the Proposed Action.

Thus, when compared to the Period of Record, modeling suggests that there will likely be an increase in the frequency of daily flows equal to or greater than 1,000 cfs but less than 6,000 cfs with the implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests that flows equal to or greater than 1,000 cfs but less than 6,000 cfs will be less in magnitude, on average, with the implementation of the Proposed Action.

8.4.1.3. High-flow Pulses

High-flow pulses are short in duration and typically follow storms (NRC 2005). What is considered a high-flow pulse can change throughout the year. For the purpose of this analysis, it is assumed that an evaluation of the flows equal to or greater than 6,000 cfs but less than 12,000 cfs can provide some understanding of the impacts that implementing the Proposed Action will have on high-flow pulses. This range is consistent with the USGS/USFWS mapping protocol in determining split channels. A split channel was defined as a “permanent”, vegetated (trees) island that is not inundated even at a “high flow” (approximately 10,000 cfs; Hardy et al 2006).

When the Proposed Action is applied to the Period of Record, modeling suggests that 3.1 percent (n = 355) of the daily average flows will be equal to or greater than 6,000 cfs but less than 12,000 cfs. This is compared to the historical flows during the Period of Record when 4.1 percent (n = 461) of the daily average flows were equal to or greater than 6,000 cfs but less than 12,000 cfs (Table 8-1). When compared to the Period of Record, modeling suggests that there will be a 0.9 percentage point decrease in the frequency of daily flows that were equal to or greater than 6,000 cfs but less than 12,000 cfs with the implementation of the Proposed Action.

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the daily flows that will be equal to or greater than 6,000 cfs but less than 12,000 cfs is 7,492 cfs. During the Period of Record, the historical average of daily flows that were equal to or greater than 6,000 cfs but less than 12,000 cfs was 7,715 cfs (Table 8-1). When compared to the Period of Record, modeling suggests that there will be a 222 cfs decrease in the average of daily flows that are equal to or greater than 6,000 cfs but less than 12,000 cfs with the implementation of the Proposed Action.

The duration of high-flow pulses is also an important aspect of the hydrograph. To better understand the impacts to the duration of high-flow pulses, the frequency of modeled high-flow pulses that are three consecutive days or greater were numerated and compared to historical flows. When the Proposed Action is applied to the Period of Record, modeling suggests that there will be 41 high-flow pulse events that will be three days or greater in duration. This is compared to the historical flows during the Period of Record when 33 high-flow pulse events were three days or greater in duration. When compared to the Period of Record, modeling suggests that there will be an increase (n = 8) in the frequency of high-flow pulse events that will be three days or greater in duration with the implementation of the Proposed Action.

Thus, with the implementation of the Proposed Action, modeling suggests that the change in the daily flows from the Period of Record will likely include a decrease in the frequency of flows equal to or greater than 6,000 cfs but less than 12,000 cfs. When compared to the Period of Record, modeling suggests the flows will likely be slightly less in magnitude, on average, with the implementation of the Proposed Action. However, when compared to the Period of Record, modeling suggests that there will be an increase in the frequency of high-flow pulses that are three days or greater in duration with the implementation of the Proposed Action.

The result of fewer high-flow pulses may result in the stabilization of gravel bars, promoting thick riparian vegetation at the river edges. The loss of high-flow pulses may also cause alluvial barriers to seasonally form at the mouths of upper Klamath River mainstem tributaries (NMFS 2012a). The reduced frequency and magnitude of high-flow pulses may further increase the flows needed to obtain overbank flow and decrease the likelihood of overbank flow occurrence (Junk et al. 1989, Poff et al. 1997).

8.4.1.4. Overbank Flow

Overbank flow is an infrequent, high-flow event that breaches riverbanks (NRC 2005). Overbank flows provide for channel and riparian maintenance (Hardy et al. 2006). PacifiCorp (2006, as cited in Hardy et al. 2006) conducted geomorphic analyses including initiation of bed load movement. These analyses suggest that the flows threshold for bed mobility below IGD was approximately 13,000 cfs (Hardy et al. 2006). For the purpose of this discussion, overbank flows are considered those flows equal to or greater than 12,000 cfs.

When the Proposed Action is applied to the Period of Record, modeling suggests that 0.2 percent (n = 24) of the daily flows will be greater than or equal to 12,000 cfs. This is compared to the historical flows during the Period of Record when 0.1 percent (n = 11) of the daily flows were equal to or greater than 12,000 cfs (Table 8-1). With the implementation of the Proposed Action, modeling suggests that the frequency of daily flows that are equal to or greater than 12,000 cfs will increase (n = 13) when compared to the Period of Record.

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the daily modeled flows that will be equal to or greater than 12,000 cfs is 14,706 cfs. During the Period of Record, the average of historical daily flows that were equal to or greater than 12,000 cfs was 14,000 cfs (Table 8-1). When compared to the Period of Record, modeling suggests there will be a 706 cfs increase in the average of daily flow that is equal to or greater than 12,000 cfs with the implementation of the Proposed Action.

Thus, when compared to the Period of Record, the frequency of flows that will be equal to or greater than 12,000 cfs will likely increase with the implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests flows that will be equal to or greater than 12,000 cfs will likely be larger in magnitude, on average, with the implementation of the Proposed Action.

8.4.1.5. Flow Variability

The consequence of a lack of variability in flows is less complexity in the habitat, and ultimately, a loss of diversity (Poff et al. 1997).

Appendix 8A-1 depicts the IGD historical daily average flows during the Period of Record, the modeled daily average flows with the implementation of the Proposed Action when applied to the Period of Record, and the modeled flows with the implementation of the VBF approach when applied to the Period of Record by water year. As noted above, there are limitations in comparing the model used to develop the VBF approach with the daily time step output used to develop the Proposed Action.

For example, implementation of the flow variability program under the VBF approach is based on in-season information. It is not feasible to model how water managers would have applied the fall and winter flow variability program prior to its implementation. In addition, the Proposed Action allows for additional flexibility in managing the water in-season. Additional in-season adjustments to the modeled Proposed Action flows analyzed in the coho salmon Effects Analysis are difficult to model because they would be determined in real-time management and be based upon current conditions.

In recognition of these limitations, when compared to the current (VBF approach) and past water management practices during the Period of Record, the Proposed Action will allow for greater daily IGD flow variability (Appendix 8A-1). Maintaining natural variability in the flow regime is critical for conserving the structure and function of a riverine ecosystem (Sanford et al. 2007). The natural riverine ecosystem is what the coho salmon have evolved under and are adapted to. The intent of this increased flow variability with the implementation of the Proposed Action is to restore a more natural riverine ecosystem, which is assumed to benefit coho salmon.

8.4.2. Impaired Water Quality

This section will evaluate how the implementation of the Proposed Action may modify water quality downstream of IGD. In particular, we will discuss impacts on water temperature, nutrient loading, and DO concentration.

8.4.2.1. Temperature

Ambient air temperatures in the fall, winter, and spring in the Klamath Basin are not at a level that result in water temperatures of concern to salmonids. However, high water temperatures that are potentially stressful to salmonids are observed during the summer (Bartholow 2005). Bartholow (2005) found that the period of high water temperatures in the Klamath River has lengthened by about one month over the period studied (1962 to 2001). Correspondently, Bartholow (2005) found that the average length of the mainstem Klamath River with cool summer temperatures (i.e., temperatures conducive to salmonid survival) has declined by about 5.1 miles/decade (8.2 kilometer [km]/decade). Water temperature trends appear unrelated to any change in mainstem water availability but are consistent with measured Basin-wide air temperature increases (Bartholow 2005).

Keno Dam is located downstream of the Project. The distance between the Keno Dam (RM 233) and IGD (RM 190) is approximately 43 RMs. In this distance, water flows through PacifiCorp's hydroelectric facilities. Given the distance between the Project and IGD, the primary drivers of water temperature released from IGD are the result of a series of reservoirs, dams, and meteorological conditions (e.g., ambient air temperatures).

However, water temperatures downstream of IGD can be influenced by the volume of the water released at IGD, particularly during the summer. The NRC (2004) found that the potential benefit from increased IGD releases during the summer is confounded by relationships between minimum, mean, and maximum temperatures. Low flows have longer transit times and are susceptible to greater exposure to environmental conditions than high flows. As discussed in the Baseline, during the summer, increased flows reduce the mean and maximum water temperatures, but increase the minimum water temperatures.

Table 8-2 provides a summary of the IGD historical average daily flows during the Period of Record and the modeled average daily flows with the implementation of the Proposed Action when applied to the same period. When compared to the Period of Record, on average, flow will increase during the summer by 102 cfs, on average, with the implementation of the Proposed Action. Thus, when compared to the Period of Record, on average, flow will increase during the summer with the implementation of the Proposed Action. Although the temperature of the water released from IGD is primarily the result of a series of reservoirs, dams, and meteorological conditions, increased summer flows will increase the minimum water temperatures further downriver. The increase in minimum temperatures may adversely affect fish that are at their limits of thermal tolerance (NRC 2004).

Table 8-2. Summary of the summer IGD historical (actual) average daily flows during the Period of Record and for the modeled average daily flows during July, August, and September with implementation of the Proposed Action.

Criteria	Modeled Proposed Action	Actual	Difference
Total Daily Flows			
Count Average Daily Flow (cfs) Percent of the Modeled Proposed Action	2,852 1,104 100.0%	2,852 1,002 90.7%	0 102 9.3%
Less than 1,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	637 22.3% 943	1,148 40.3% 758	-511 -17.9% 185
Greater than or equal to 1,000 cfs but less than 6,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	2,215 77.7% 1,151	1,704 59.7% 1,166	511 17.9% -16
Greater than or equal to 6,000 cfs but less than 12,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	0 0.0% 0	0 0.0% 0	0 0.0% 0
Greater than or equal to 12,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	0 0.0% 0	0 0.0% 0	0 0.0% 0

8.4.2.2. Nutrient Loading

The highly eutrophic outflow from UKL confounds the ability to separate water quality effects of the Project operation from other factors (NMFS 2010). Two sources of nutrients into the

Klamath River from the Project include the LRDC (RM 249, 58.7 miles upstream of IGD) and the Klamath Strait Drain (RM 239.4, 48.9 miles upstream of IGD). The water returned from the Project has a higher concentration of nutrients. However, this return water enters an already highly nutrient rich system with the net load of nutrients downstream of Keno Dam (RM 232.9) being reduced by the Project. Thus, the Project operation results in a net "sink" for Klamath River nutrients.

However, ODEQ (2010) concluded in 2002, that even though the Project appears to be a net sink of nutrients, it also appears to have detrimental impacts to the water quality of the Klamath River. In 2002, the Project's return of a higher concentration of nutrients increased the nutrient concentration within the Keno Impoundment Reach. This higher concentration of nutrients within the Keno Impoundment Reach resulting from Project operations must still pass through a series of reservoirs, dams, and continued meteorological conditions. Thus, how this increase in nutrient concentration within the Keno Impoundment Reach impacts the nutrient concentration below IGD i not known at this time. However, increased nutrient concentrations downstream of IGD may impact DO concentrations.

8.4.2.3. Dissolved Oxygen (DO)

During fall, winter, and spring, with the exception of immediately downstream of IGD, DO concentrations are typically at or near saturation (PacifiCorp 2012). Low DO concentrations immediately downstream of IGD do occur. These low DO concentrations are largely driven by the effects of the PacifiCorp Hydroelectric Project (NMFS 2007a) and the highly eutrophic outflow from UKL.

During the summer, low DO concentrations do occur further downstream of IGD (PacifiCorp 2012). As discussed in the Baseline, IGD flow adjustments that are the result of Project operations may impact water depth and therefore influence the daily swings of DO. Lower water depths may result in lower daily minimum DO concentrations. The Project operations may also influence periphyton growth. Increasing periphyton biomass would increase the magnitude of the daily swings in DO and therefore decreases daily minimum DO levels.

When compared to the Period of Record, flows will increase during the summer by 102 cfs, on average, with the implementation of the Proposed Action (Table 8-2). Thus, when compared to the Period of Record, on average, flows will increase during the summer with the implementation of the Proposed Action. Increased summer flows will increase the water depth. Increased water depth may result in higher daily minimum DO concentrations further downriver.

8.4.3. Stressors Specific to the Implementation of the Proposed Action

Based on the above discussions, the following ecological effects, as measured downstream of IGD, **will not be** carried forward in this analysis as stressors to coho salmon caused by the implementation of the Proposed Action.

> *Temperature:* Given the distance between the Klamath Project and IGD, the primary drivers of the water temperature of IGD releases are the result of the effects of PacifiCorp's hydroelectric facilities and meteorological conditions (e.g., ambient air temperatures).

Nutrient Load: The implementation of the Proposed Action will reduce the overall nutrient load from UKL downstream of Keno Dam.

DO Concentrations: During the fall, winter, and spring the influence of the Klamath Project operations on DO concentrations downstream of IGD is likely to be negligible.

The following ecological effects, as measured downstream of IGD, **will be** carried forward in this analysis as a stressor, adverse or beneficial, on coho salmon with the implementation of the Proposed Action.

Subsistence Flows: When compared to the Period of Record, modeling suggests that there will likely be a reduction in the frequency of daily flows that are less than 1,000 cfs with the implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests that flows that are less than 1,000 cfs will be greater in magnitude, on average, with the implementation of the Proposed Action.

Base Flows: When compared to the Period of Record, modeling suggests that there will likely be an increase in the frequency of daily flows equal to or greater than 1,000 cfs but less than 6,000 cfs with the implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests that flows equal to or greater than 1,000 cfs but less than 6,000 cfs will be less in magnitude, on average, with the implementation of the Proposed Action.

High-flow Pulses: With the implementation of the Proposed Action, modeling suggests that the change in the daily flows from the Period of Record will likely include a decrease in the frequency of flows equal to or greater than 6,000 cfs but less than 12,000 cfs. When compared to the Period of Record, modeling suggests the flows will likely be slightly smaller in magnitude, on average, with the implementation of the Proposed Action. However, when compared to the Period of Record, modeling suggests that there will be an increase in the frequency of high-flow pulses that are three days or greater in duration with the implementation of the Proposed Action.

Overbank Flows: When compared to the Period of Record, the frequency of the flows that were equal to or greater than 12,000 cfs will likely increase with the implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests flows will likely be larger in magnitude, on average, with the implementation of the Proposed Action.

Flow Variability: When compared to past and current water management practices during the Period of Record, the Proposed Action will allow for greater flow variability for the intended benefit of coho salmon.

Nutrient Concentration: The Project's return of a higher concentration of nutrients increases the nutrient concentration within the Keno Impoundment Reach. How this increase in nutrient concentration within the Keno Impoundment Reach impacts the nutrient concentration below IGD as a result of the Proposed Action is not known at this time.

Temperature: Although the water temperature released from IGD are primarily the result of a series of reservoirs, dams, and meteorological conditions. Compared to the Period of Record during the summer, increased IGD releases as a result of the Proposed Action would lower the mean and maximum water temperatures further downriver. In addition, the minimum daily water temperature would also increase through reduced effects of nocturnal cooling. When compared to the Period of Record, on average, flow will increase during the summer with the implementation of the Proposed Action.

DO Concentrations: When compared to the Period of Record, on average, flows will increase during the summer with the implementation of the Proposed Action. Increased summer flows will increase the water depth. Increased water depth may result in higher daily minimum DO concentrations further downriver.

8.5. Exposure to Stressors and Response of Individual Coho Salmon

The purpose of this section is to define the spatial and temporal co-occurrence of coho salmon with the stressors identified above. This section will also assess how coho salmon will likely respond to the stressors specific to the implementation of the Proposed Action. Following this assessment, Reclamation will make one of the following determinations: No effect; May affect, but not likely to adversely affect; or May affect, likely to adversely affect.

8.5.1. Spatial Exposure

The impacts of Project operations diminish downstream of IGD as tributary (Appendix 8A-7) and other environmental influences increase. For example, based on the mean monthly discharge for the Period of Record, IGD discharge (United States Geological Survey [USGS] gauge 11516530) represented a minimum of eight percent of the discharge (in February) and a maximum of 37 percent of the discharge (in September; Appendix 8A-16). Actual percentage of IGD contribution to the lower Klamath River would be less since this assessment directly compares the discharge at IGD to the flow at the mouth of the Klamath River (USGS gauge 11530500). This assessment assumes no evaporative or seepage loss of IGD releases during the 185.2 miles between these two Klamath River gauges.

Prior to IGD, flows at the current site of IGD may have varied even more than what is analyzed here. For example, there are pictorial records of Link River with no flows during the summer of 1918 (Appendix 8A-15). Link River is a short river connecting UKL to Lake Ewauna. Lake Ewauna is the headwaters of the Klamath River. UKL is the major source of water at IGD during the summer. During the Period of Record, the lowest Link River flow during the summer was 134 cfs.

8.5.2. Temporal Exposure and Response

The temporal analysis of exposure and response to stressors will be structured by life-stage. Our analysis will begin with the adult and continue through the life cycle. In the following analysis, Reclamation considers fall to include October, November, and December; winter to include

January, February, and March; spring to include April, May, and June; and summer to include July, August, and September.

Typically coho salmon spend half of their life in the marine environment. As discussed in the Baseline, marine salmon survival during ocean rearing depends on a number of interrelated factors, including the abundance of prey, density of predators, the degree of intra-specific competition (including that from hatchery fish), and fisheries. The importance of these factors in turn depends on ocean conditions. Even relatively small changes in local and annual fluctuations in marine water temperature can be related to changes in salmon survival rates. For the purpose of this analysis, changes in annual ocean productivity are considered a Baseline condition. However, since the Action Area for the Proposed Action does not include the marine environment. The following impact discussion on the adult life stage will begin at the freshwater upstream migration.

8.5.2.1. Adult Freshwater Migration

Adult freshwater migration occurs from October through mid-December (Figure 7, page 58 in NMFS 2010).

Connectivity: Fish require a minimum depth of flow to allow them to reach swimming potential (Dane 1978). Total submergence eliminates a fish's risk of oxygen starvation, allows the fish to create maximum thrust, and lowers the risk of bodily injury through contact with the bottom (Forest Practices Advisory Committee on Salmon in Watersheds 2001 as cited USDA 2009).

As mentioned earlier, in 2010, NMFS determined that a mainstem flow of 1,000 cfs is expected to provide sufficient flow to maintain connectivity to tributaries for re-distributing juvenile coho salmon. Upstream migrating adult coho salmon would generally require more depth than juveniles for passage. Thus, flows less than 1,000 cfs may also hinder adult salmon upstream migration, particularly into the tributaries of the mainstem. An evaluation of flows less than 1,000 cfs during the fall can provide insight into the potential for blockage of upstream migration of coho salmon.

When the Proposed Action is applied to the Period of Record, modeling suggests that 21.0 percent (n = 598) of the daily average flows will be less than 1,000 cfs during the fall (Table 8-3). This is compared to the historical flows during the Period of Record when 16.7 percent (n = 475) of the daily average flows were less than 1,000 cfs (Table 8-3). When compared to the Period of Record, modeling suggests that there will be a 4.3 percent increase in the frequency of fall daily average flows that are less than 1,000 cfs with the implementation of the Proposed Action.

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the fall daily modeled flows that are less than 1,000 cfs is 960 cfs (Table 8-3). During the Period of Record, the actual average of the fall daily flows that were less than 1,000 cfs was 902 cfs (Table 8-3). When compared to the Period of Record, modeling suggests that there will be a 58 cfs increase in the average of fall daily flows that are less than 1,000 cfs with the implementation of the Proposed Action.

Although modeling suggests that flows less than 1,000 will occur slightly more frequently during the fall, the average of the flows less than 1,000 are greater than during the Period of Record. Thus, when compared to the Period of Record, it is unlikely that the implementation of the Proposed Action will have an appreciable impact on the mainstem migration of adult coho salmon through blockage due to low flows.

Table 8-3. Summary of the Iron Gate Dam historical (actual) average daily flows during October, November, and December during the Period of Record (October 1, 1980 to September 30, 2011, and for the modeled average daily flows during October, November, and December with the implementation of the Proposed Action when applied to the same period.

Criteria	Modeled Proposed Action	Actual	Difference
Total Daily Flows			
Count Average Daily Flow (cfs) Percent of the Modeled Proposed Action	2,852 1,402 100.0%	2,852 1,691 117.3%	0 -249 -17.3%
Less than 1,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	598 21.0% 960	475 16.7% 902	123 4.3% 58
Greater than or equal to 1,000 cfs but less than 6,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	2,224 78.0% 1,482	2,339 82.0% 1,758	-115 -4.0% -275
Greater than or equal to 6,000 cfs but less than 12,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	30 1.1% 7,996	38 1.3% 7,429	-8 0.3% -567
Greater than or equal to 12,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	0 0.0% 0	0 0.0% 0	0 0.0% 0

Temperature: NRC (2004) speculated that while the cause of the 2002 fish kill was likely a combination of factors, it is likely that water temperature and not flow was the primary contributor to inhibiting upstream migration in 2002. As discussed previously, during the summer, increased IGD releases would lower the mean and maximum water temperatures further downriver. In addition, the minimum daily water temperature would also increase through reduced effects of nocturnal cooling. Due to ambient temperature influences, IGD release impacts on water temperature are significantly reduced below the Shasta River and have little impact on water temperature below Siead Valley (NRC 2004). Thus, it is unlikely that the implementation of the Proposed Action will have an appreciable impact on the mainstem migration of adult coho salmon through temperature effects.

8.5.2.2. Mainstem Spawning

Spawning occurs from November through January (Figure 7, page 58 in NMFS 2010). Dunne et al. (2011) concluded that only a relatively small portion of natural spawning coho salmon occurs in the mainstem of the Klamath River.

As discussed in the Baseline, coho salmon spawning in the mainstem Klamath River have been observed during IGD releases[33] ranging from a low of 882 cfs to a high of 1,650 cfs. Table 8-3 provided a summary of the IGD historic average daily flows during the Period of Record and for the modeled average daily flows with the implementation of the Proposed Action when applied to the same period. Modeling suggests that the majority of the flows with the implementation of the Proposed Action during the fall will be within the levels where mainstem spawning has been observed in the past. Thus, when compared to past observations, implementation of the Proposed Action will provide similar opportunities for spawning.

8.5.2.2. Carcass Redistribution

As discussed in the Baseline, high-flow pulses are needed to effectively redistribute mainstem salmon carcasses. Not effectively redistributing mainstem carcasses may increase the likelihood of disease transmission.

For the purpose of this BA, it is assumed that an evaluation of the flows equal to or greater than 6,000 cfs but less than 12,000 cfs can provide some understanding of the impacts of implementing the Proposed Action on high-flow pulses during the fall. When compared to the Period of Record, modeling suggests that the frequency of IGD releases equal to or greater than 6,000 cfs but less than 12,000 cfs will decrease by 8 events during the fall with the implementation of the Proposed Action (Table 8-3).

Thus, when compared to the Period of Record, the decrease in frequency of high-pulse flows during the fall with the implementation of the Proposed Action may increase the likelihood of disease transmission. However, this impact may be reduced due to an increase in the magnitudes, on average, of those high-pulse flows. When compared to the Period of Record, modeling suggests that the magnitude of the flows during the fall that are equal to or greater than 6,000 cfs but less than 12,000 cfs will increase by 567 cfs, on average, with implementation of the Proposed Action (7,996 cfs compared to 7,429 cfs; Table 8-3).

In addition, as discussed in the Baseline, salmonids in the Klamath River are exposed to a number of pathogens and diseases that can impact all coho salmon life stages. Disease effects vary annually based on water temperature, water year, and other factors. In field studies, the effects of flow and temperature are difficult to separate from those of infectious dose and mortality of fish. At this time, no conclusions on the impacts of the Project on adult coho salmon mortality due to disease are inconclusive.

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[33] As measured at USGS gauge 11516530.

8.5.2.3. Mainstem Incubation of Eggs and Alevins

Incubation occurs from November through March (Figure 7, page 58 in NMFS 2010). Dunne et al. (2011) concludes that only a relatively small portion of natural spawning coho salmon occurs in the mainstem of the Klamath River. Therefore, only a small proportion of total incubating eggs and alevins will be directly influenced by implementing the Proposed Action.

Base flow is the "normal" flow condition between storms (NRC 2005). What is considered base flow may change during the egg incubation and alevin development period. Fluctuation in flows within a given water year from the levels experienced during mainstem spawning can impact survival of eggs and alevins, particularly if the redds become dewatered. Fluctuation in flows occurs under natural conditions.

For the purpose of this discussion, an evaluation of flows equal to or greater than 1,000 cfs but less than 6,000 cfs can provide some understanding of the impacts of implementing the Proposed Action on base flows. Comparing the base flow during the fall to the base flow during the winter can also provide some understanding on the potential for the dewatering of redds.

During the Period of Record, the average fall base flow was 1,758 cfs compared to the average winter base flow of 2,406 cfs, an increase of 648 cfs during the period of egg incubation and alevin development. With the implementation of the Proposed Action, the average fall base flow was 1,482 cfs compared to the average winter base flow of 2,374 cfs, an increase of 892 cfs. Based on the above base flow comparison, when compared to the Period of Record, the likelihood of dewatering events is reduced with implementation of the Proposed Action.

8.5.2.4. Mainstem Fry

When most of the yolk sac is absorbed, the alevins emerge from the gravel as fry. Within the Klamath River, fry primarily emerge in mid-February and continue through mid-April (Figure 7, page 58 in NMFS 2010).

Habitat Availability: Hardy et al. (2006) provides coho salmon fry habitat availability curves for a given flow and by reach (Appendix 8A-4). Appendix 8A-12 depicts the flow-habitat relationship (i.e., habitat availability curves) for the R. Ranch and Trees of Heaven Reaches. The R. Ranch Reach is immediately downstream of IGD. Downstream of the R. Ranch Reach is the Trees of Heaven Reach. Flows from IGD have the most influence on these two reaches.

Assuming 100 adult coho salmon spawners,[34] Table 8-4 provides an estimate of the number of coho salmon fry produced in the mainstem of the Klamath River. Fry are non-territorial and most probably stay in the mainstem tributaries close to the areas in which they were spawned (NRC 2004). However, downstream movement of fry in the spring to the mainstem Klamath River does occur (Koski 2009). The extent of this re-distribution to the mainstem is unknown.

[34] Assumption made in Ackerman et al 2006: 100 mainstem spawners is considered a optimistic estimate for the 10-year period of this BA. In recent redd surveys, only 13 mainstem coho salmon redds have been observed in the mainstem area surveyed.

Table 8-4 uses the same assumptions Nicholson (1998) used in modeling coho salmon production; fecundity was assumed to be 2,500 eggs per female and the sex ratio was assumed to be one-to-one. In addition, Koski (1966) found the mean survival to emergence from 21 redds in three Oregon coastal streams was 27.1 percent (range of 13. 6 percent to 54. 4 percent). This is consistent with the average coho salmon fecundities, as determined by other researchers working on streams in British Columbia, Washington, and Oregon (CDFG 2012). These researchers had a range from 1,983 to 2,699 and averaged 2,394 eggs per female. Available research indicates that larger coho salmon produce more eggs and there is a definite tendency for fecundity to increase from California to Alaska (CDFG 2012).

NMFS found that an abundance of coho salmon fry habitat is predicted throughout the entire Upper Klamath River reach under the Proposed Action outlined in Reclamation's 2007 BA and analyzed in the NMFS' 2010 BO (Figures 18-20 in NMFS 2010). Reclamation currently operates under the VBF approach which approximates the flows analyzed in the BO.

Appendix 8A-12 depicts the fry habitat availability curves for the R. Ranch and Trees of Heaven Reaches. In general, the combined available fry habitat for these two reaches decrease above 3,000 cfs. In addition, for the Trees of Heaven Reach, there is little change in the available fry habitat between 1,000 and 30,000 cfs. In addition, for these two reaches, the available fry habitat under the Proposed Action, the VBF approach and the available fry habitat during the Period of Record are very similar (Appendix 8A-5 and Appendix 8A-6).

Given an optimistic estimate of the number of mainstem fry production, the likely limited re-distribution of fry from the tributaries, along with the non-territorial nature of fry, mainstem coho salmon fry will most likely experience adequate quantities of suitable fry habitat with the implementation of the Proposed Action.

Stranding: Fry are generally at the most risk from stranding compared to other salmonid life stages due to their swimming limitations and their propensity to use margins of the channel (NMFS 2010). Stranded fry [and juvenile] coho salmon disconnected from the main channel are more likely to experience fitness risks, be more susceptible to predators, and be exposed to poorer water quality (NMFS 2010). Mid-February through mid-May is the time when fry are present in the mainstem.

Table 8-4. Estimate of the number of eggs, fry, and juvenile coho salmon produced in the mainstem of the Klamath River.

Life Stage	Number	Source
Number of Mainstem Coho Salmon Spawners	100 Adults	Ackerman et al. 2006
Number of Females	50 Females	Nicholson 1998
Number of eggs (50 females x 2,500 eggs)	125,000 eggs	Nicholson 1998
Fry (125,000 x 0.271)	33,875 Fry	Koski 1996
Summer Juveniles (125,000 x 0.072 percent)	9,000 Juveniles	Nicholson 1998

Flows equal to or greater than 6,000 but less than 12,000 cfs increases the chances of stranding fry. With the implementation of the Proposed Action, modeling suggests that daily flows between 6,000 to 12,000 cfs will occur during the winter 7.9 percent of the time (n = 220; Table 8-5). With the implementation of the Proposed Action, modeling suggests that daily flows equal to or greater than 6,000 but less than 12,000 cfs will occur during the spring 3.7 percent of the time (n = 105; Table 8-6). When compared to the Period of Record (historical flows), the frequency of equal to or greater than 6,000 to 12,000 cfs was slightly reduced with the implementation of the Proposed Action.

Table 8-5. Summary of Iron Gate Dam historical (actual) average daily flows during January, February, and March during the Period of Record (October 1, 1980 to September 30, 2011), and for the modeled average daily flows during January, February, and March with the implementation of the Proposed Action when applied to the same period.

Winter Criteria	Modeled Proposed Action	Actual	Difference
Total Daily Flows			
Count Average Daily Flow (cfs) Percent of the Modeled Proposed Action	2,797 2,601 100.0%	2,797 2,821 108.4%	0 -220 -8.4%
Less than 1,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	591 21.1% 959	415 14.8% 790	176 6.3% 169
Greater than or equal to 1,000 cfs but less than 6,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	1,962 70.1% 2,374	2,065 73.8% 2,406	-103 -3.7% -32
Greater than or equal to 6,000 cfs but less than 12,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	220 7.9% 7,717	306 10.9% 7,973	-86 3.1% -256
Greater than or equal to 12,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	24 0.9% 14,706	11 0.4% 14,000	13 0.5% 706

Flows equal to or greater than 12,000 cfs also increase the chance of stranding fry. With implementation of the Proposed Action, modeling suggests that daily flows equal to or greater than 12,000 will occur during the winter 0.9 percent of the time (n = 24; Table 8-5). With implementation of the Proposed Action, modeling suggests that daily flows equal to or greater than 12,000 cfs will not occur during the spring (Table 8-6). This is consistent with the Period of Record. When compared to the Period of Record the frequency of equal to or greater than 12,000 cfs flows will increase slightly with the implementation of the Proposed Action.

Based on the above comparisons, the likelihood of fry being stranded is very similar between the Period of Record and implementation of the Proposed Action.

IGD Ramp-Down Rates: While stranding of fry salmonids can occur under a natural hydrograph, artificially excessive ramp-down rates could exacerbate stranding risks. Death from desiccation may occur as a result of excessive ramp-down rates.

NMFS (2010) has not required, nor has Reclamation proposed, daily or hourly ramp down rates when the flow release at IGD is greater than 3,000 cfs. When flows at IGD exceed 3,000 cfs, Reclamation and PacifiCorp generally treat hydrological fluctuations as run-of-the-river and flows at IGD generally follow the rate of natural decline. In 2010, NMFS (p. 111, 2010) expected any stranding that may occur at flows higher than 3,000 cfs to be consistent with rates that are observed under natural conditions.

> When the flow at IGD is equal to or less than 3,000 cfs, ramp down rates with the implementation of the Proposed Action are similar to the current ramp down rates:
>
> Decreases in flows of 300 cfs or less per 24-hour period and no more than 125 cfs per 4-hour period when IGD flows are above 1,750 cfs, or
>
> Decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per 2-hour period when IGD flows are 1,750 cfs or less.

NMFS concluded in their 2002 BO that ramp down rates below 3,000 cfs, as outlined above, adequately reduce the risk of stranding juvenile [and fry] coho salmon (p. 111, NMFS 2010). In 2010, NMFS concluded that the IGD operational ramp-down rates are not likely to adversely affect juvenile [and fry] coho salmon. In addition, NRC (p. 25, 2008) found the IGD ramping rates are sufficient for the protection of coho salmon. These determinations are applicable to the ramp rate component of the Proposed Action.

8.5.2.5. Mainstem Juveniles

Lestelle (2010) has provided a conceptual model of seasonal habitat use and movement patterns by juvenile coho salmon in the Klamath Basin. Consistent with the organization used in the Baseline, Reclamation will use this same general structure to evaluate impacts to juveniles with the implementation of the Proposed Action.

8.5.2.5.1. Spring Re-distribution/Rearing

As discussed in the Baseline, juvenile salmonids relocate in order to avoid adverse environmental conditions or to optimize foraging opportunities, although it is likely that most juvenile coho salmon continue to remain within their natal tributary to rear. The general trend during the spring re-distribution/rearing period is for small scale movements within the tributaries to deeper water and for large scale movements to be in an upstream direction toward cooler tributaries (Hay 2004). It is also likely that some mainstem produced juveniles migrate into the tributaries during the spring. Likewise, some tributary juvenile coho salmon are likely to be displaced into the mainstem Klamath River.

Connectivity: Navigating shallow channel sections is inherently less troublesome for juvenile than adult fish due to their smaller size. In 2010, NMFS determined that a 1,000-cfs mainstem flow is expected to provide sufficient flow to maintain connectivity to tributaries for re-distributing juvenile coho salmon. With the implementation of the Proposed Action, modeling suggests that 4.9 percent of the spring flows will be less than 1,000 cfs (n = 139; Table 8-6). The average of the modeled flows below 1,000 cfs is 949 cfs. During the Period of Record, 19.7 percent of the spring flows were less than 1,000 cfs (n = 555; Table 8-6). The average of the historical flows below 1,000 cfs was 722 cfs. Thus, when compared to the Period of Record, implementing the Proposed Action will improve connectivity for individual coho salmon juveniles to the tributaries during the spring re-distribution period.

Available Habitat: Hardy et al. 2006 provided available juvenile habitat in square feet per 1,000 linear feet of the Klamath River for each reach within their study area. The R. Ranch Reach is from IGD to the Shasta River (RM 190.5 to RM 177.3; Appendix 8A-4), 13.2 miles or 69,696 feet. The upper boundary of the Trees of Heaven Reach is the confluence with the Shasta River. For the purpose of this analysis, it was assumed that the Trees of Heaven Reach was from RM 177.3 (Shasta River) to RM 160.6, a total of 16.7 miles (88,176 feet).

In expanding available habitat into potential numbers of fish, Nickelson's (1998) habitat based potential coho salmon capacity of approximately 0.19 fish per square feet (2.0 individuals per square meter) was used for this analysis. Nickelson et al. (1992b) found that the estimates of potential coho salmon smolt capacity generated by a model have been shown to be closely related to actual smolt production when summer habitat was fully seeded with juveniles of approximately 1.5 to 2.0 juveniles/square meters of pool. Based on this evaluation, Reclamation estimated the number of juvenile coho salmon potential based on the available habitat (Appendix 8A-14).

Table 8-6. Summary of Iron Gate Dam historical (actual) average daily flows during April, May, and June during the Period of Record (October 1, 1980 to September 30, 2011, and for the modeled average daily flows during April, May, and June with the implementation of the Proposed Action.

Criteria	Modeled Proposed Action	Actual	Difference
Total Daily Flows			
Count Average Daily Flow (cfs) Percent of the Modeled Proposed Action	2,821 2,453 100.0%	2,821 2,193 89.4%	0 206 10.6%
Less than 1,000 cfs			
Count Percent of Total Count Average Daily Flow (cfs)	139 4.9% 949	555 19.7% 722	-416 -14.7% 227
Greater than or equal to 1,000 cfs but less than 6,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	2,577 91.4% 2,354	2,149 76.2% 2,304	482 15.2% 50

Criteria	Modeled Proposed Action	Actual	Difference
Greater than or equal to 6,000 cfs but less than 12,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	105 3.7% 6,876	117 4.1% 7,131	-12 -0.4% -255
Greater than or equal to 12,000 cfs			
Count Percent of Total Average Daily Flow (cfs)	0 0.0% 0	0 0.0% 0	0 0.0% 0

Assuming 100 adult coho salmon natural spawners, Table 8-4 provides an estimate of the number of coho salmon juveniles produced (9,000 juveniles) in the mainstem of the Klamath River. Based on Hardy et al. (2006) juvenile habitat availability curves (Appendix 8A-13), the number of juvenile coho salmon potential based on available habitat (i.e., intrinsic habitat potential) for the R. Ranch and Trees of Heaven Reaches, individually and combined (Appendix 8A-14) was also estimated. Comparing the available habitat to the estimate of the number of coho salmon juveniles produced in the mainstem, the data suggests that natural-origin juvenile coho salmon will experience adequate quantity of habitat to support the relatively small portion of natural-origin coho salmon juvenile residing within the mainstem during the winter. This analysis assumes distribution of fish would allow full utilization of habitat within these two reaches.

There are also an unknown number of juveniles (age 0+; e.g., young of the year) that may re-distribute to the mainstem. In addition, an unknown number of juveniles within the mainstem may re-distribute to the tributaries during the spring. However, the use of 100 natural mainstem spawners is optimistic and would most likely account for a portion or all juveniles that may relocate for the tributaries to the mainstem. Under most flows, the analysis suggests that the habitat in the R. Ranch and Trees of Heaven Reaches could support over 20,000 coho salmon. Based on the available habitat, it is likely that implementing the Proposed Action will provide adequate habitat for natural-origin juvenile coho salmon during the spring re-distribution period. However, hatchery-origin coho salmon will also be present and be in competition for available habitat.

The hatchery at Iron Gate releases juvenile coho salmon. The hatchery program's annual goal is to produce 75,000 coho salmon for release between March 15 and May 1 (California HSRG 2012), a period when natural-origin juvenile coho salmon are rearing within the mainstem Klamath River. These hatchery-origin coho salmon will be rearing in the wild prior to migrating and likely will be in competition with natural-origin salmon.

There is limited information on the extent of intraspecific competition or predation by hatchery coho salmon yearlings with their wild counterparts. Modeling indicates that hatchery coho salmon releases likely take less than 6 percent of the natural juvenile coho salmon population (CDFG 2011). At this time, the impacts of implementing the Proposed Action on juvenile coho salmon within the mainstem following the release of hatchery-origin coho salmon are unknown. However, given the availability of coho salmon juvenile habitat within the R. Ranch and Trees of

Heaven Reaches, "take" as a result of hatchery releases may be greater than modeled by CDFG (2011).

Appendix 8A-14 estimates the number of juvenile coho salmon potential based on available habitat for the R. Ranch and Trees of Heaven Reaches. At optimal flows, approximately 50,000 Coho salmon juveniles can be supported within the R. Ranch and Trees of Heaven Reaches combined. The hatchery goal for a release of 75,000 coho salmon juveniles is greater than the juvenile coho salmon potential based on available habitat for the R. Ranch and Trees of Heaven Reaches combined. It is likely that fish rearing in the mainstem will experience decreased growth, increased or premature emigration, increased competition for food, decreased feeding territory sizes, and increased mortalities following the release of 75,000 hatchery-origin coho salmon. This assessment does not take into account competition or predation by hatchery-origin or natural-origin Chinook salmon and steelhead.

8.5.2.5.2. Summer Rearing/Re-Distribution

Klamath River below IGD (RM 190) often reaches daytime maximum temperatures over 25°C (Bartholow 2005), well above what is considered optimal temperatures for juvenile salmonids (Brett 1952; USEPA 2003).

As discussed in the Baseline, summer thermal refugia are typically identified as areas of cool water created by inflowing tributaries, springs, seeps or through upwelling hyporheic flow (Hatch et al. 2006), and groundwater (Gilbert et al. 1997) in an otherwise thermally warm-wetted stream channel. Thermal refugia provide a short-term refuge in systems where ambient temperatures during the summer exceed the tolerance of salmonids (Lestelle 2007).

Temperature: During the summer, increased IGD releases would lower the mean and maximum water temperatures further downriver. In addition, the minimum daily water temperature would increase through reduced effects of nocturnal cooling. During the Period of Record, the average summer flow was 1,002 cfs, while the average summer flow with implementation of the Proposed Action is 1,104 cfs, a difference of +102 cfs (Table 8-2). Thus, when compared to the Period of Record, implementation of the Proposed Action will increase IGD releases during the summer. This increase in flow could increase the minimum daily water temperature and add additional stress to juvenile coho salmon rearing in the mainstem.

Thermal Refugia: Mainstem thermal refuge areas are susceptible to dilution through mainstem flows. There is, however uncertainty regarding summer flow impacts on thermal refugia and further study is needed. Deas (et. al 2006) concluded that attempts to manage refugia temperatures through mainstem flow management is not recommended due to the highly variable nature of refugia from year-to year and overall minimal impacts that mainstem flows have on refugial areas with regard to temperature modification compared to meteorological effects.

The NRC (2002) also speculated that increased main-stem Klamath River releases might reduce the size of thermal refugia by causing more effective mixing of the small amounts of locally derived cool water with much larger amounts of warm water from points upstream. In a subsequent review, the NRC (2008) found that available information provides little support for benefits presumed to occur through the increase of flows during the summer beyond those of the past decade.

Sutton et al. (2007) observed salmonids residing in the mainstem Klamath River thermal refugia with IGD flow releases ranging from 615 to 1,320 cfs. The average modeled summer flows with the implementation of the Proposed Action is 1,104 cfs (Table 8-2). The flows modeled with the implementation of the Proposed Action are typically within the flows Sutton et al. (2007) observed. Thus, it is likely that implementation of the Proposed Action will maintain mainstem thermal refugia used by juvenile coho salmon consistent with past observations.

Connectivity: NMFS (2010) determined that a 1,000 cfs flow is expected to provide sufficient flow to maintain connectivity to tributaries for rearing of juvenile coho salmon. When compared to the Period of Record, modeling suggests that the frequency of IGD releases less than 1,000 cfs will decrease 17.9 percent during the summer with implementation of the Proposed Action (Table 8-2). In addition, when compared to the Period of Record, modeling suggests the magnitude of flows during the summer that are less than 1,000 cfs will be greater on average, with the implementation of the Proposed Action (Table 8-2).

Thus, when compared to the Period of Record, modeling suggests that implementing the Proposed Action will improve conditions for individual coho salmon re-distributing during the summer. However, with the implementation of the Proposed Action, modeling suggests that flows less than 1,000 cfs will still occur 22.3 percent of the time during the summer. Only a limited number of juvenile coho salmon will likely be impacted by this restriction. In addition, little re-distribution occurs within the coho salmon population during the months of July, August, and September. The one exception is the observed movement between mainstem habitat and thermal refugia located near tributary confluences and within the lower sections of some creeks (NMFS 2010).

DO Concentration: As mentioned earlier, when compared to the Period of Record, on average, flows will increase during the summer with the implementation of the Proposed Action (Table 8-2). Increased summer flows will increase the water depth. Increased water depth may result in higher daily minimum DO concentrations. Thus, when compared to the Period of Record, implementing the Proposed Action could increase the daily minimum DO levels. Increased daily minimum DO levels during the summer could reduce stress of juvenile coho salmon rearing in the mainstem.

8.5.2.5.3. Fall Re-distribution/Rearing

Connectivity: When compared to the Period of Record, modeling suggests that the frequency of IGD daily flows that are less than 1,000 cfs will increase 4.3 percent during the fall with the implementation of the Proposed Action (Table 8-3). Thus, when compared to the Period of the Record, modeling suggests that implementing the Proposed Action will decrease the ability of individual coho salmon to redistribute within the mainstem and to the tributaries during the fall redistribution. Although, when compared to the Period of Record, modeling suggests that the magnitude of the flows that are less than 1,000 cfs are greater, on average (960 cfs compared to 902 cfs; 58 cfs increase), with the implementation of the Proposed Action during the fall (Table 8-3). In addition, with the implementation of the Proposed Action, the majority (78.0 +

1.1 = 79.1 percent of total) of the fall daily flows will be equal to or greater than 1,000 cfs (Table 8-3).

Habitat Availability: The number of juveniles in the tributary that re-distribute during the fall to the mainstem of the Klamath River is unknown. However, findings from out-of-basin studies suggest that the percentage of tributary coho salmon that would likely re-distribute in the fall would be low (Ackerman and Cramer 2007). Based on Hardy et al. (2006) juvenile habitat availability curves (Appendix 8A-13) and an estimate of the number of juvenile coho salmon potential based on available habitat (Appendix 8A-14), it is anticipated that the natural-origin juvenile coho salmon will experience adequate quantities of suitable habitat to support the relatively small portion of natural-origin coho salmon rearing in the mainstem (Table 8-3) or using the mainstem to re-distribute during the fall.

In 2010, NMFS came to the same conclusion, stating that due to the low abundance of juvenile coho salmon present in this time period, habitat reductions will not result in adverse effects to individuals (NMFS 2010). When compared to the Period of Record, it is likely that implementing the Proposed Action will have little to no impact on juvenile coho salmon during the fall re-distribution/rearing period.

Flow Variability: NMFS has recently speculated that a loss of mainstem flow variability will likely reduce the environmental cues that coho salmon experience. When compared to the current management under the VBF approach, implementation of the Proposed Action will allow for greater flow variability at IGD (Appendix 8A-1). In addition, during fall freshets, mainstem individuals will likely experience environmental cues other than IGD flow, such as changes to ambient temperature, barometric pressure (NMFS 2010), and through accretions downstream of IGD.

8.5.2.5.4. Winter Re-distribution/Rearing

As mentioned earlier, juvenile coho salmon have been observed successfully accessing tributaries when IGD base flows have been 1,000 cfs (Soto et al. 2008 as cited in NMFS 2010).

Connectivity: When compared to the Period of Record, modeling suggests that the frequency of IGD releases less than 1,000 cfs will increase 6.3 percent during the winter with the implementation of the Proposed Action (Table 8-5). Thus, when compared to the Period of Record, implementing the Proposed Action will decrease the ability of individual coho salmon to re-distribute within the mainstem and to the tributaries during the winter period. However, the extent of re-distribution (to and from the tributaries and within the mainstem) during the winter is less for fish residing in the mainstem Klamath River upstream of Happy Camp (RM 110). Due primarily to accretions, IGD releases have limited physical impacts below Happy Camp, particularly during the winter **(**Appendix 8A-7).

Available Habitat: Assuming 100 adult coho salmon natural spawners, Table 8-4 provides an estimate of the number of coho salmon juveniles produced in the mainstem of the Klamath River. Based on Hardy et al. (2006) juvenile habitat availability curves (Appendix 8A-13), Reclamation also estimated of the number of juvenile coho salmon potential based on available habitat (i.e., intrinsic habitat potential) for the R. Ranch and Trees of Heaven Reaches, combined (Appendix 8A-14).

Comparing available habitat to an estimate of the number of coho salmon juveniles produced in the mainstem suggests that natural-origin juvenile coho salmon will experience an adequate quantity of habitat to support the relatively small portion of natural-origin coho salmon juvenile residing within the mainstem during the winter. This analysis assumes distribution of fish would allow full utilization of habitat within these two reaches. There are also an unknown number of juveniles (age 0+; i.e., young of the year) that may re-distribute to the mainstem or juveniles within the mainstem that redistribute to the tributaries. Reclamation's use of 100 natural mainstem natural spawners is optimistic during the 10-year period of the Proposed Action and would account for a portion of all juveniles that may relocate from the tributaries to the mainstem.

However, the hatchery program's annual goal is to produce 75,000 coho salmon for release between March 15 and May 1 (California HSRG 2012), a period when natural-origin juvenile coho salmon are rearing within the mainstem Klamath River. These hatchery-origin coho salmon will be rearing in the wild prior to migrating and likely will be in competition with natural-origin salmon. The extent of intraspecific competition or predation by hatchery coho salmon yearlings with their wild counterparts during residency is unknown (CDFG 2011). While these possible impacts have not been quantified, modeling indicate that hatchery coho salmon releases likely take less than 6 percent of the natural juvenile coho salmon population (CDFG 2011). Given the availability of coho salmon juvenile habitat within the R. Ranch and Trees of Heaven Reaches, take may be more.

Appendix 8A-14 estimates the number of juvenile coho salmon potential based on available habitat for the R. Ranch and Trees of Heaven Reaches. The hatchery release is greater than the juvenile coho salmon potential based on available habitat for the R. Ranch and Trees of Heaven Reaches combined. This assessment does not take into account competition or predation by hatchery-origin Chinook salmon and steelhead. At this time, the impacts of implementing the Proposed Action on juvenile coho salmon within the mainstem following the release of hatchery-origin coho salmon are unknown. However, it is likely that fish rearing in the mainstem will experience decreased growth, increased or premature emigration, increased competition for food, decreased feeding territory sizes, and increased mortalities following the release of 75,000 hatchery-origin coho salmon.

8.5.2.6. Smolt Outmigration

Natural-origin coho salmon smolts upon entering the mainstem Klamath River from their natal tributary generally tend to begin their downstream movement quickly (Stutzer et al. 2006). Hatchery-origin coho salmon have similar out-migration timing within the mainstem Klamath River. Thus, impacts to natural-origin and hatchery-origin coho salmon smolt from the Proposed Action during outmigration are assumed to be similar.

Transit Time: While there has been conflicting discussion on the topic of flow effects on emigration survival (Anderson 2003), it is generally accepted that survival increases with increasing discharge in free flowing river reaches (Cada et al. 1993). Thus, higher flows in the mainstem Klamath River in April and May probably decrease transit time of the smolt. Low transit time could reduce predation rates and reduce energy consumption in swimming, although this has not been demonstrated in the Klamath River (NRC 2004). When compared to the Period of Record, modeling suggests that the magnitude of the flows during the spring are greater (2,453 cfs compared to 2,193 cfs), on average, with the implementation of the Proposed Action (Table 8-6). Thus, when compared to the Period of Record, modeling suggests that implementing the Proposed Action will reduce the travel time, on average, for individual coho salmon smolt migrating out of the Upper Klamath Basin.

Disease: Salmonids in the Klamath Basin are exposed to a number of pathogens and diseases that can impact all life stages. Disease effects vary annually based on water temperature, water year, and other factors. As discussed in the Baseline, field studies show that the effect of flow and temperature are difficult to separate from those of infectious dose and mortality of fish. Thus, the influences of Project operations on infection rates of smolts through flow and temperature are difficult to discern (NMFS 2010). At this time, information is not available to determine the impacts of flow and temperature on coho salmon smolts mortality through disease during the spring out-migration period.

8.5.3. Summary of Risks to Individual Coho Salmon

Based on the above discussions, coho salmon will be exposed to environmental consequences and will respond in a negative manner to the exposure. When compared to the Period of Record, the effects of the Proposed Action that are likely to cause an adverse effect to federally-listed coho salmon include:

Adult: When compared to the Period of Record, the decrease in frequency of high-pulse flows during the fall with implementation of the Proposed Action may increase the likelihood of disease transmission. Although, this impact may be reduced by an increase in the average magnitude of the high-pulse flows.

Juvenile during summer: With implementation of the Proposed Action, modeling suggests that flows less than 1,000 cfs will occur 22.3 percent of the time during the summer. Flows less than 1,000 cfs may impact the ability of individual coho salmon to redistribute to the tributaries**.**

Implementation of the Proposed Action will increase IGD releases during the summer. This increase in flow could increase the minimum daily water temperature and add additional stress *to* juvenile coho salmon rearing in the mainstem.

Implementation of the Proposed Action will increase the nutrient concentration within the Keno Impoundment Reach. How a higher nutrient concentration within the Keno Impoundment Reach correlates with the nutrient concentration below IGD is not known at this time.

Juvenile during fall: Implementing the Proposed Action will decrease the ability of individual coho salmon to redistribute within the mainstem and to the tributaries during the fall re-distribution period. With the implementation of the Proposed Action, modeling suggests that fall flows less than 1,000 cfs will occur 21.0 percent of the time during the fall.

Juvenile during winter: Implementing the Proposed Action will decrease the ability of individual coho salmon to redistribute within the mainstem and to the tributaries during the winter. Modeling suggests that winter flows less than 1,000 cfs will occur 21.1 percent of the time with implementation of the Proposed Action.

At this time, the impacts of implementing the Proposed Action on juvenile coho salmon within the mainstem following the release of hatchery-origin coho salmon are unknown. However, it is likely that fish rearing in the mainstem will experience decreased growth, increased or premature emigration, increased competition for food, decreased feeding territory sizes, and increased mortalities following the release of 75,000 hatchery-origin coho salmon.

Smolts: Modeling suggests that implementing the Proposed Action will reduce the travel time, on average, for individual coho salmon smolt migrating out of the Upper Klamath Basin.

At this time, information is not available to determine the impacts of flow and temperature on coho salmon smolt mortality through disease.

8.5.4. Determination of Effects on the SONCC Coho Salmon ESU

After considering the best available scientific and commercial information, the analysis indicates SONCC coho salmon are likely to be exposed to environmental consequences and will respond in a negative manner to the exposure. Thus, Reclamation concludes that implementing the Proposed Action may affect, and is likely to adversely affect the SONCC coho salmon ESU.

8.6. Evaluation of Impacts on Designated Coho Salmon Critical Habitat

This section of the BA will evaluate if the Proposed Action may affect designated critical habitat of the SONCC coho salmon ESU. Following this evaluation, Reclamation will make one of the following determinations: “No effect," which means there will be no impacts, positive or negative, to designated critical habitat of the SONCC coho salmon ESU; "May affect, but not likely to adversely affect," which means that all effects are beneficial, insignificant, or discountable; or "May affect, and is likely to adversely affect," which means that designated critical habitat for the SONCC coho salmon ESU is likely to be exposed to the Proposed Action or its environmental consequences and will respond in a negative manner to the exposure.

In particular, this section evaluates whether implementation of the Proposed Action is likely to reduce the quantity, quality, or availability of the critical habitat’s constituent elements essential for the conservation of the species. The final determination assesses if, with implementation of the Proposed Action, critical habitat would remain functional to serve the intended conservation role for the SONCC coho salmon ESU or retain its current ability to establish those features and functions essential to the conservation of the species.

8.6.1. Evaluation of Impacts on the Essential Habitat Types

The essential habitat types of SONCC coho salmon ESU designated critical habitat are:

1. Juvenile summer and winter rearing areas.
2. Juvenile migration corridors.
3. Adult migration corridors.

4. Spawning areas.
5. Areas for growth and development to adulthood.

Areas for growth and development to adulthood is restricted to the marine environment for coho salmon and not impacted by the implementation of the Proposed Action. In addition, implementing the Proposed Action will only impact designated critical habitat within the mainstem of the Klamath River downstream of IGD.

Juvenile Summer Rearing Areas:
As mentioned in the Baseline, the Klamath River mainstem often reaches daytime maximum temperatures well over 25°C during the summer (Bartholow 1995); well above optimal temperatures for juvenile salmonids. In the Klamath River, juvenile coho salmon have been observed utilizing areas of cooler water, such as those found at the confluences of cold water tributaries, to escape potentially lethal mainstem water temperatures. These areas, known as thermal refugia, are important because they allow fish to utilize mainstem habitats that otherwise would be unavailable to them due to high water temperatures.

Thermal refugia are highly variable in time and space and there are many factors that can impact the size, shape, and function of the refugia from a physical characterization perspective (Deas et al. 2006). IGD flows can influence both the amount and extent of refugial habitat in the mainstem Klamath River. Deas et al. (2006) found that for a certain range of flows,[35] the refugia thermal conditions were largely unchanged. Deas et al. (2006) also found that above certain flow thresholds, refugial areas generally changed in lateral and longitudinal extent, and decreased in overall size. The flow threshold when thermal conditions changed varied by individual refugia. Deas et al. (2006) further concluded that the effects of meteorological conditions or tributary contributions played a larger role in refugial conditions than flow changes at IGD.

Sutton et al. (2007) observed salmonids residing in the mainstem Klamath River thermal refugia with IGD flow releases ranging from 615 cfs to 1,320 cfs. Only one modeled daily flow is below 615 cfs during the summer (less than 0.1 percent of total). The modeled summer flows with the implementation of the Proposed Action (Appendix 8A-1) are typically within the flows Sutton et al. (2007) observed.

Juvenile Winter Rearing Areas:
Hardy et al. (2006) conducted mesohabitat (pool, run, low slope, moderate slope, and steep slope) mapping for eight study sites throughout the mainstem Klamath River (Appendix 8A-4). The habitat mapping results were utilized to model relationships between flow and available fish habitat within specific study sites.

These study site locations were chosen to be broadly representative of channel characteristics within each delineated river reach and in some cases to overlap with existing USGS/ USFWS

[35] The highest flow observed during the study was 1,320 cfs in 2004.

System Impact Assessment Model[36] study sites (Hardy et al. 2006). These site-level results were then expanded to estimate the available habitat for the entire study reach through the use of aerial photogrammetry image acquisition and digital terrain modeling (Hardy et al. 2006).

Based on Hardy et al. (2006) habitat mapping results for the R. Ranch Reach, the estimated weighted useable area (in square feet of habitat per linear 1,000 feet) of juvenile habitat for the R. Ranch Reach under flow at the 25 percent, 50 percent, and 75 percent exceedances are depicted in Figure 8-1 for several scenarios: the historic flows during the Period of Record, for the Proposed Action applied to the Period of Record, and for the VBF procedure applied to the Period of Record.

However, there are limitations in comparing the annual 17 time step output from the model used to develop the VBF approach with the daily time step output used to develop the Proposed Action. For example, it is not feasible to model how water managers would have implemented the fall and winter flow variability program in prior years. Implementation of the flow variability program is based on in-season information.

With the exception of very low flows, (e.g., 75 percent exceedance), available winter juvenile habitat within the R. Ranch Reach is very similar under the historical flows during the Period of Record, for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record (Figure 8-1). At lower flows, the Proposed Action provides for slightly less habitat.

[36] The Klamath River System Impact Assessment Model is a decision support system developed by the U.S. Geological Survey to study the effects of Basin-wide water management decisions on anadromous fish in the Klamath River.

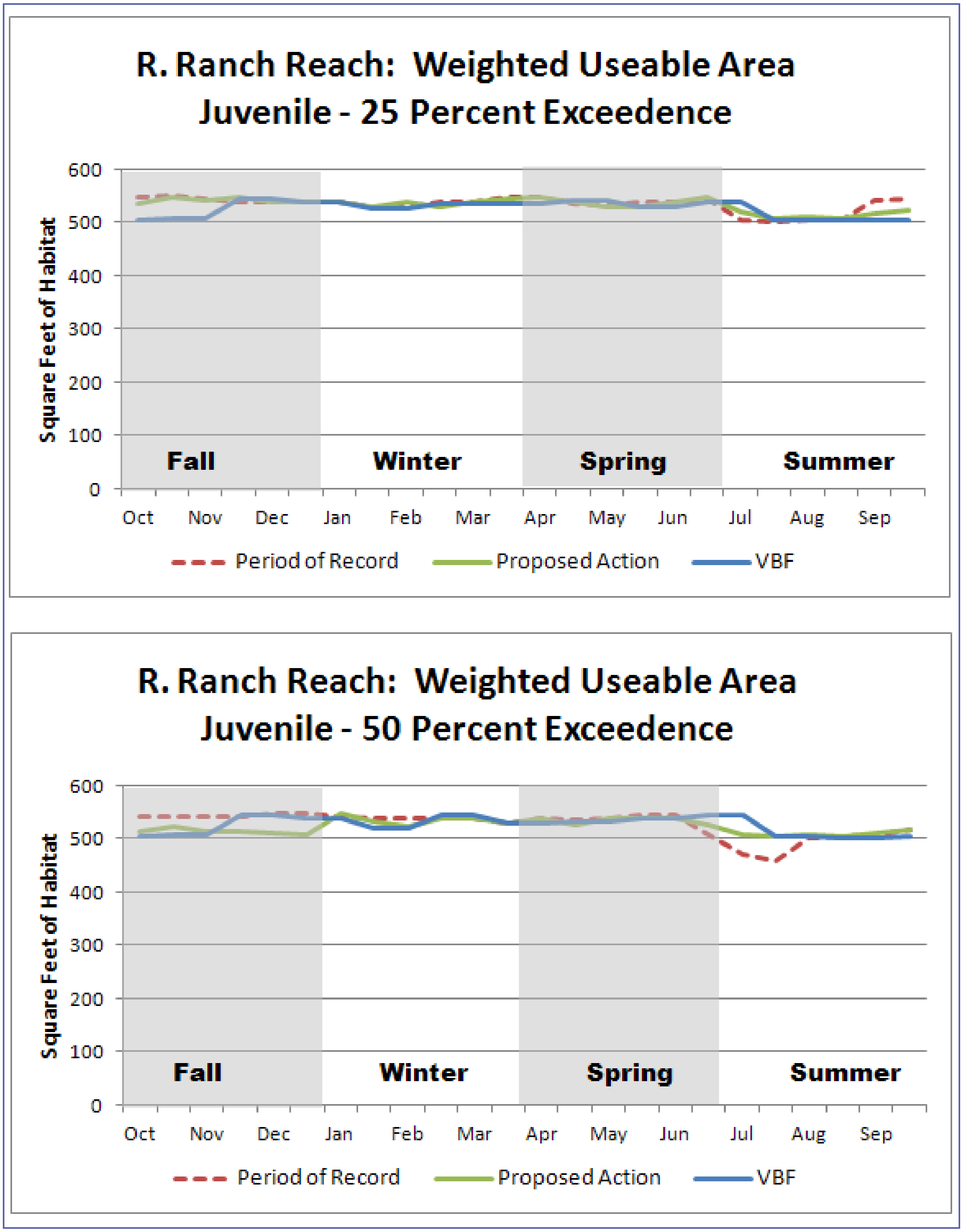

Figure 8-1. Square feet of coho salmon juvenile habitat at the 75 percent, 50 percent, and 25 percent exceedance levels for the Period of Record (Historical; October 1, 1980 to September 30, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record, R. Ranch Reach. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

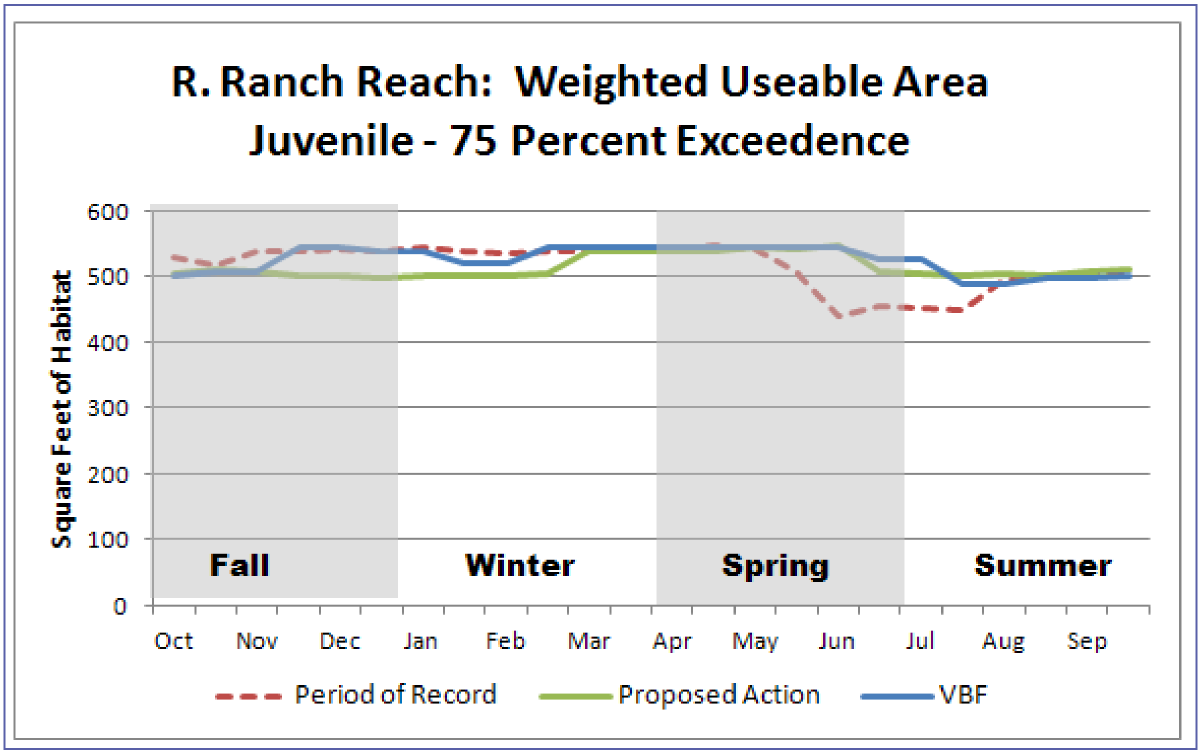

Figure 8-1 (Continued). Square feet of coho salmon juvenile habitat at the 75 percent, 50 percent, and 25 percent exceedance levels for the Period of Record (Historical; October 1, 1980 to September 30, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record, R. Ranch Reach. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

Figure 8-2 depicts the estimated available juvenile habitat for the Trees of Heaven Reach under flow at the 25 percent, 50 percent, and 75 percent exceedances for the historic flows during the Period of Record, for the Proposed Action applied to the Period of Record, and for the VBF procedure applied to the Period of Record. These flows represent discharge flows from IGD only and do not represent the accretions from multiple creeks, shallow groundwater inflow, and inflows from the Shasta and Scott Rivers. Thus, the estimated IGD flows that were applied directly to the Trees of Heaven Reach in this evaluation should be considered conservative.

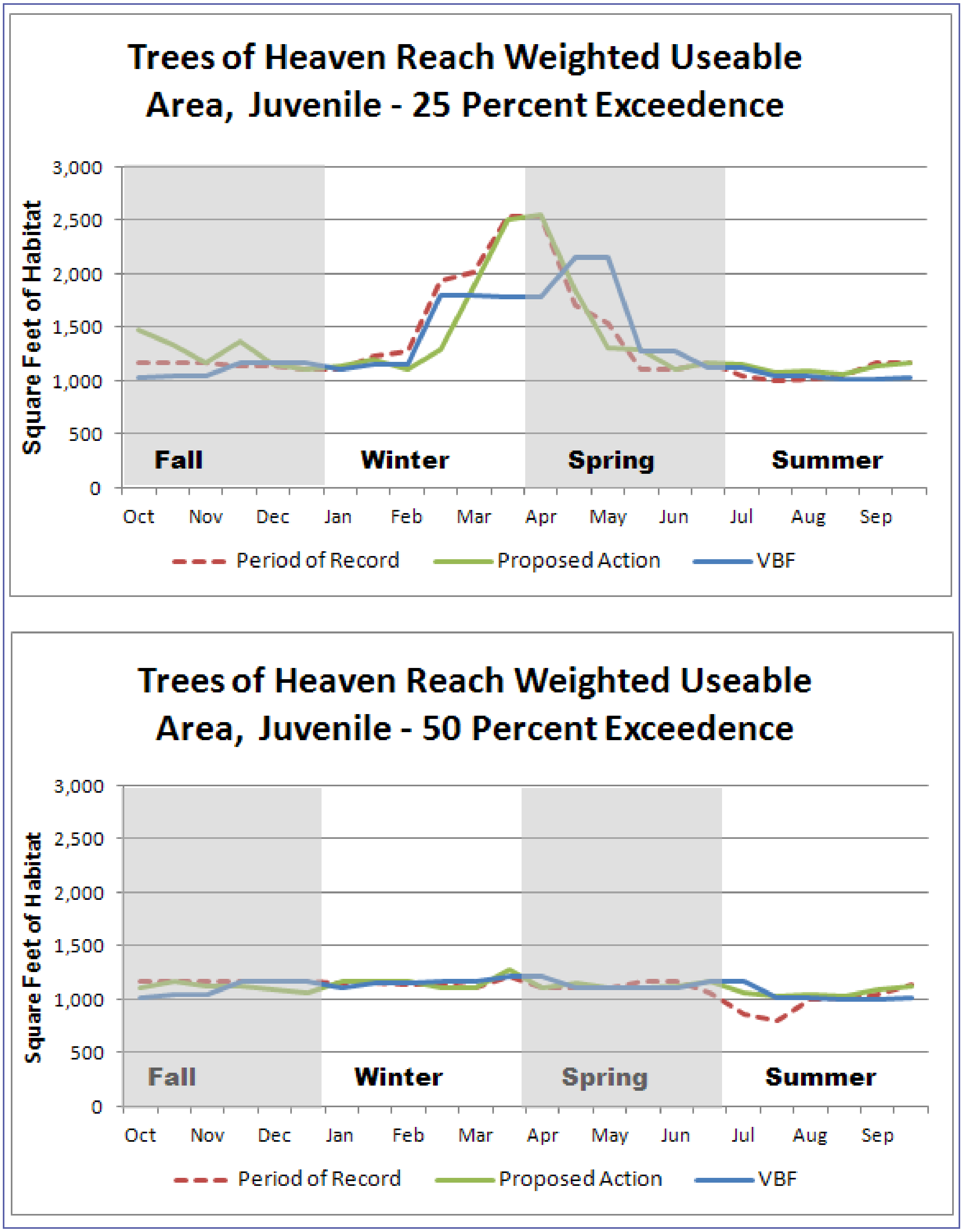

Figure 8-2. Square feet of coho salmon juvenile habitat at the 25 percent, 50 percent, and 75 percent exceedance levels for the Period of Record (Historical; October 1, 1980 to September 30, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record, Trees of Heaven Reach. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

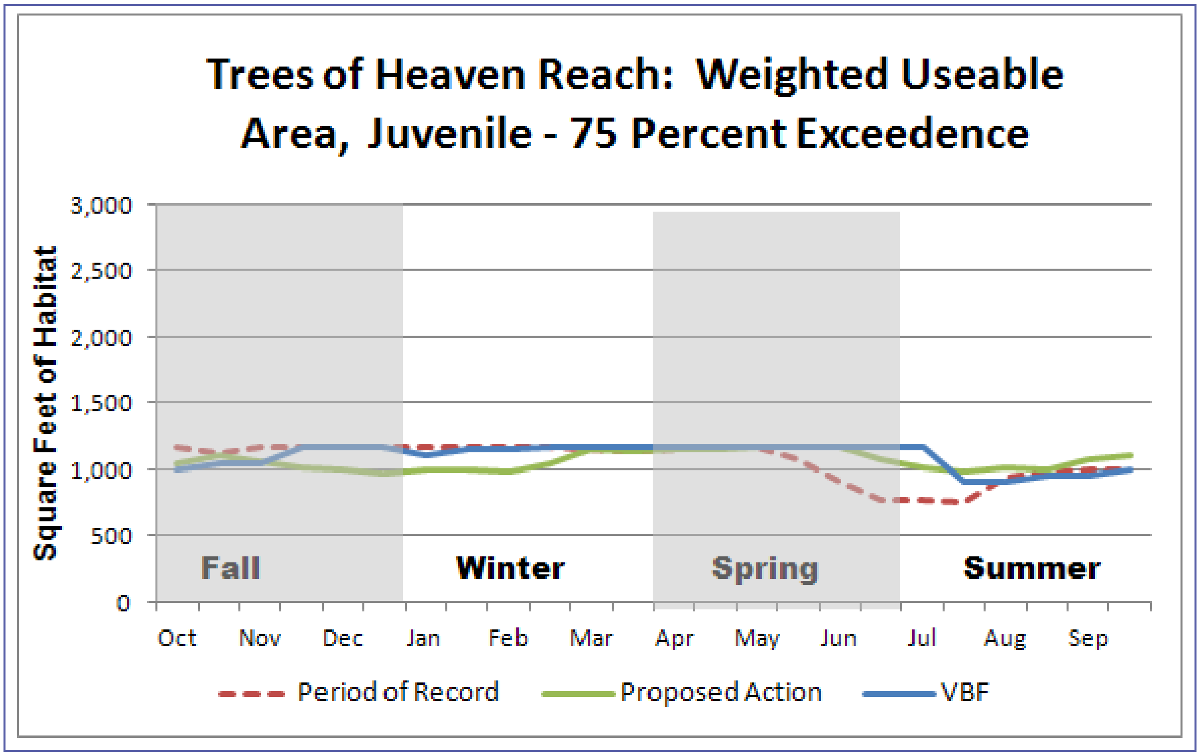

Figure 8-2 (Continued). Square feet of coho salmon juvenile habitat at the 25 percent, 50 percent, and 75 percent exceedance levels for the Period of Record (Historical; October 1, 1980 to September 30, 2011), for the Proposed Action applied to the Period of Record, and for the Variable Base Flow (VBF) procedure applied to the Period of Record, Trees of Heaven Reach. *Flow-Habitat Relationship Source: Appendix I, Hardy et al. 2006.*

At higher exceedance levels (e.g., 75 percent exceedance; dryer conditions), available winter juvenile habitat within the Trees of Heaven Reach are very similar under the historical flows during the Period of Record and for the VBF procedure applied to the Period of Record (Figure 8-2). At lower flows, the Proposed Action provides for slightly less habitat.

At lower exceedance levels (e.g., 25 percent exceedance; wetter conditions), available winter juvenile habitat within the Trees of Heaven Reach is very similar under the historical flows during the Period of Record and for the Proposed Action applied to the Period of Record (Figure 8-2). At these higher flows, the VBF procedure provides for slightly less winter habitat (Figure 8-2).

Juvenile Migration Corridor:

The mainstem can be used for both movement and migration of coho salmon, but they are not necessarily the same thing. Reclamation assumes that migration in the context of critical habitat is considered the directed migration into or out of the Klamath River drainage. For the purpose of this discussion, the relocation within the drainage by rearing juvenile or fry coho salmon is considered “movement”. Thus, juvenile migration corridor habitat primarily addresses the habitat used by out-migration of coho salmon smolts during the spring. Water depth is an essential feature of migratory habitat. Water velocity is also a critical factor likely influencing the speed at which coho salmon smolts migrate through the mainstem channel.

Navigating shallow channel sections is inherently less troublesome for juvenile fish than adult fish due to their smaller size. In 2010, NMFS determined a 1,000-cfs mainstem flow is expected to provide sufficient flow to maintain connectivity to tributaries for re-distributing juvenile coho salmon.

When the Proposed Action is applied to the Period of Record on an annual basis, modeling suggests that 17.4 percent (n = 1,965) of the daily average flows are less than 1,000 cfs. This is compared to the historical flows during the Period of Record when 22.9 percent (n = 2,593) of the daily average flows were less than 1,000 cfs (Table 8-1). When compared to the Period of Record, modeling suggests that there will be a 5.5 percent decrease in the frequency of daily average flows that are less than 1,000 cfs with the implementation of the Proposed Action.

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the daily modeled flows that are less than 1,000 cfs is 953 cfs. During the Period of Record, the historical average of the daily flows that were less than 1,000 cfs was 782 cfs (Table 8-1). When compared to the Period of Record, modeling suggests that there will be a 171 cfs increase in the average of the flows that are less than 1,000 cfs with implementation of the Proposed Action.

Thus, when compared to the Period of Record, modeling suggests that there will likely be a reduction in the frequency of daily flows that are less than 1,000 cfs with implementation of the Proposed Action. In addition, when compared to the Period of Record, modeling suggests that flows that are less than 1,000 cfs will be greater in magnitude, on average, with implementation of the Proposed Action.

Adult Migration Corridor:
The Proposed Action will affect water volume and velocity within the mainstem, which are the two essential habitat features that affect fish passage dynamics downstream of IGD. Water depth is an essential feature of adult migratory habitat, with greater depths allowing easier access into tributary habitat.

In 2010, NMFS determined a 1,000-cfs mainstem flow is expected to provide sufficient mainstem flow to maintain connectivity to tributaries for re-distributing juvenile coho salmon. Flows less than 1,000 cfs may hinder adult salmon upstream migration, particularly into the tributaries of the mainstem. Freshwater migration for adult coho salmon occurs during the fall.

During the fall, when the Proposed Action is applied to the Period of Record, modeling suggests that 21.0 percent (n = 598) of the daily average flows are less than 1,000 cfs. This is compared to the historical flows during the Period of Record when 16.7 percent (n = 475) of the daily average flows were less than 1,000 cfs during the fall (Table 8-3). When compared to the Period of Record, modeling suggests that there will be a 4.3 percent increase in the frequency of fall daily average flows that are less than 1,000 cfs with the implementation of the Proposed Action.

In addition, when the Proposed Action is applied to the Period of Record, modeling suggests that the average of the fall daily modeled flows that are less than 1,000 cfs is 960 cfs. During the Period of Record, the historical average of the fall daily flows that were less than 1,000 cfs was 902 cfs (Table 8-3). When compared to the Period of Record, modeling suggests there will be a 58 cfs increase in the average of fall daily flows with implementation of the Proposed Action.

Although modeling suggests that flows less than 1,000 cfs will occur slightly more frequently during the fall, the average of the flows less than 1,000 cfs will be greater than during the Period of Record. Thus, when compared to the Period of Record, it is unlikely that the implementation of the Proposed Action will have an appreciable impact on the mainstem migration of adult coho salmon through blockage due to low flows.

Spawning Areas:
Spawning areas for SONCC coho salmon must include adequate substrate, water quality, water quantity, water temperature, and water velocity to ensure successful redd building, egg deposition, and egg to fry survival.

Spawning occurs from November through January, with the peak occurring from mid-November through December. Magneson and Gough (2006) observed coho salmon spawning in the mainstem Klamath River during IGD releases[37] ranging from a low of 882 cfs to a high of 1,650 cfs. Implementing the Proposed Action will provide flows above the level where mainstem spawning has been observed during the fall (Table 8-3).

8.6.2. Evaluation of Impacts on the Conservation Value of Designated Coho Salmon Critical Habitat

8.6.2.1. Juvenile Summer and Winter Rearing Areas

Although the effects of IGD releases on the amount of refugia habitat in the mainstem is not well understood, implementation of the Proposed Action will likely provide for adequate habitat with sufficient velocities and depth suitable for summer rearing of coho salmon juveniles.

At higher exceedance levels (e.g., 75 percent exceedance; dryer conditions), available winter juvenile habitat within the R. Ranch and Trees of Heaven Reaches is very similar under the historical flows during the Period of Record and for the VBF procedure applied to the Period of Record. At these lower flows, the Proposed Action provides for slightly less winter habitat. However, juvenile rearing areas will likely function in a manner that supports its intended conservation role with implementation of the Proposed Action.

8.6.2.2. Juvenile Migration Corridor

The Proposed Action will affect water volume and velocity within the mainstem. However, juvenile migration corridors will likely function in a manner that supports its intended conservation role.

[37] As measured at USGS gauge 11516530.

8.6.2.3. Adult Migration Corridor

With the implementation of the Proposed Action, the hydrologic conditions of the adult migration corridor will likely support adequate passage.

8.6.2.4. Spawning Areas

Reclamation anticipates that during the peak coho salmon spawning period of November and December, implementation of the Proposed Action will likely provide adequate water velocities and depths to support spawning and subsequent egg incubation and alevin development within mainstem redds.

8.6.3. Determination of Effects on Designated Coho Salmon Critical Habitat

Considering best available scientific and commercial information, implementing the Proposed Action may affect, and is likely to adversely affect designated coho salmon critical habitat. However, the conservation values of designated coho salmon critical habitat will likely function in a manner that supports its intended conservation role.

8.7. Cumulative Effects (Impacts of Future State, Tribal, Local, or Private Actions)

Cumulative effects include the impacts of future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area (50 C.F.R. 402.02). Cumulative effects are discussed below.

8.7.1. Fish Hatcheries

The information available indicates that the influence of the hatchery stocking program on the genetic fitness of natural-origin coho salmon populations in the Klamath and Trinity Rivers is significant. NMFS (2010) stated that they anticipated hatchery releases to remain constant into the near future. The future condition for naturally produced coho salmon populations may be further degraded due to detrimental impact from density-dependent mechanisms in the freshwater environment. For example, mainstem natural-origin juvenile coho salmon during the winter rearing period may be significantly impacted when the effects of future releases of juvenile salmonids from Iron Gate Hatchery are added to the environment.

8.7.2. Habitat Restoration

There is various restoration and recovery actions underway in the Klamath Basin aimed at improving habitat and water quality conditions for anadromous salmonids (NMFS 2010). Restoration activities may include future state, tribal, local, or private actions, thus included here.

Dunne et al. (2011) found that restoration efforts are currently improving habitat in tributaries downstream of IGD, but the extent of changes and their effect on populations or even use of the habitat are undocumented (or at least in the reports supplied to the Panel). Some of these efforts apparently began years ago; yet, increases in some species such as coho salmon that depend on tributary habitat are not apparent.

NMFS (2010) stated those beneficial effects from restoration activities are expected to continue through at least 2018, and possibly increasing during that time period. However, Dunne et al. (2011) speculated that the degree of mitigation provided by restoration efforts might not be sufficient to offset climate change adverse effects that will occur within the system (e.g., loss of thermal refugia) and in the ocean, especially on coho salmon. Dunne et al. (2011) further concluded that under climate change, it is reasonable to expect tributaries to warm by a few degrees, although neither measurements nor model predictions were available for these critical spawning and rearing environments.

8.7.3. Agriculture Practices

Agricultural operations, if unaltered, will continue to reduce the quantity and alter the timing of water availability and may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for ESA-listed coho salmon by increasing erosion and sedimentation, as well as introducing nitrogen, ammonia, and other nutrients into the watershed. Storm water and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect salmonid reproductive success and survival rates.

8.7.4. Timber Harvest

In general, recent timber management activities allow more water to reach the ground, and may alter water infiltration into forest soils such that less water is absorbed or the soil may become saturated faster, thereby increasing surface flow. Road systems, skid trails, and landings where the soils become compacted may also accelerate runoff (NMFS 2010).

Although the adverse effects from timber harvest are expected to continue for the 10-year duration of the Proposed Action, and for years to follow, improved future Baseline condition will likely occur as adverse effects from past poor timber management practices decrease through time.

8.7.5. Mining

Although the adverse effects from mining are expected to continue for the 10-year duration of the Proposed Action, and for years to follow, future Baseline conditions will likely improve as adverse effects from past poor mine management practices decrease through time.

8.8. Jeopardy Determination Considerations

A considerable number of studies furthering the understanding of Klamath River coho salmon have been authorized, funded or otherwise carried out by the Klamath Basin tribes, the State of California, and USFWS. The reference section includes these and many other reports that were reviewed and/or cited in the preparation of this BA. In addition, Reclamation also acknowledges the following comprehensive reports that were funded, in part, by the Department of the Interior and cited throughout the coho salmon sections:

Hardy, T. B., R. C. Addley and E. Saraeva. 2006. Evaluation of Flow Needs in the Klamath River Phase II. Final Report. Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan, Utah 84322-4110. Prepared for U. S. Department of the Interior. July 31. 229 p.

Lestelle, L.C. 2007. A Review of Coho Salmon Life History Patterns in the Pacific Northwest and California for Reference in Assessing Population Performance in the Klamath River Basin. Prepared for U.S. Bureau of Reclamation, Klamath Area Office. July 21. 101 pp.

National Research Council (NRC). 2004. Endangered and Threatened Fishes in the Klamath River Basin: Causes of decline and strategies for recovery. Prepared for the National Academy of Science by the National Research Council, Division on Earth and Life Studies, Board on Environmental Studies and Toxicology, Committee on Endangered and Threatened Fishes in the Klamath River Basin. Washington, D.C. 358 p.

National Research Council (NRC). 2008. Hydrology, Ecology, and Fishes of the Klamath River Basin, National Academic Press, Washington, D.C., 249 pp.

In regards to Hardy et al 2006, NRC (2008) found several aspects of the Hardy Phase II Study praiseworthy. NRC found the measurement of stream-bed topography and substrate characteristics in the Hardy Phase II Study representative of innovative, cutting-edge methods that provided generally useful representations of the river channels. The two-dimensional hydrodynamic model in the Hardy Phase II Study represented the state-of-the-art application of flow models in simulating habitats (NRC 2008). The flow-habitat relationship curves provided in Hardy et al. 2006 were used throughout the salmon affects analysis within this BA.

In addition, in making its jeopardy determination, NMFS should consider the Klamath Coho Salmon Life-Cycle Model. The Klamath Coho Salmon Life-Cycle Model was developed to evaluate the effects of water management alternatives (i.e., incremental differences in flow at IGD) between two alternatives on ESA-listed SONCC coho salmon. The coho salmon model is in the process of being revised and is currently undergoing in-Basin stakeholder and independent peer review. As with any model, there are strengths and weakness in its utility. Recognizing the coho salmon life-cycle model's limitations, the coho salmon model can provide useful output for exploring both relative differences between alternatives and predictions of population abundance at equilibrium.

Comparing predictions of absolute abundance to empirically derived abundance estimates for the Shasta River and Scott River basins reveals that predictions were reasonably accurate, though a perfect comparison is difficult to make since modeled values were intended to represent mean production levels at population equilibrium. However, the variation in model predictions did seem representative of the natural variation in actual smolt and adult production. Modeled freshwater and marine survivals for these two subbasins also aligned relatively well with survival estimated directly from empirical abundances (Table 8-7).

Preliminary analysis of modeled output finds that survival within the tributaries and in the ocean is highly variable and accounts for most of the variation observed in coho salmon production. The greater variation in survival observed for coho salmon during life outside of the mainstem Klamath River is congruent with model results that show limited ability of flow manipulations at IGD to alter coho salmon production.

Table 8-7. Preliminary comparison of model predicted coho salmon abundance and survival values observed for populations in the Scott and Shasta Rivers since 2001. Observed values from Chesney and Knechtle (2011).

Location	Scott River		Shasta River	
	Model Value	Observed Range	Model Value	Observed Range
Smolts to Tributary Mouth	10,988	941 – 75,097	4,684	169 – 11,052
Spawners Entering Tributary	298	62 – 1,622	91	9 – 373
Smolt-to-Adult Return	4.4%	1.5 – 8.6%	4.4%	0.8 – 4.3%
Smolts/Spawner	38.1	34.5 – 38.4%	51.5	4.4 – 38.0

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Part 9 OTHER SPECIES

The following discusses the impacts of implementing Reclamation's Klamath Project, the Proposed Action, on southern Distinct Population Segment (DPS) of green sturgeon, southern Resident DPS killer whale, and southern DPS North American Pacific eulachon. Additional species biological information may be found in Appendix 9A.

9.1. Southern DPS Green Sturgeon

The North American green sturgeon is comprised of two populations that are both discrete and significant as defined in the DPS policy. The northern DPS consists of coastal populations ranging from the Eel River northward. The southern DPS includes any coastal or central valley populations south of the Eel River, with the only known population being in the Sacramento River. The NMFS' (2005) updated status review provided new and updated green sturgeon information on genetic analyses, oceanic distribution and behavior, freshwater distribution, and catch data. This more complete genetic analyses indicates there is a clear split between the southern green sturgeon DPS and the northern green sturgeon DPS.

The Proposed Action will not inhibit marine migration of southern DPS green sturgeon to the Klamath River estuary zone during the spring/summer when occupancy is known to occur. Project operations are not expected to alter, reduce, or change the availability of food resources in the estuary zone. Project operations could modulate temperature conditions in the estuary zone during the summer period when flows in the summer are provided, but the dilutive effects of the ocean would tend to moderate any potential for temperature increases which could potentially adversely impact the southern green sturgeon DPS.

Reclamation concludes that conditions in the estuary under the Proposed Action are not expected to be significantly different than the current condition; therefore, the Proposed Action may affect, but is not likely unlikely to adversely affect the green sturgeon southern DPS.

Critical habitat for the southern DPS green sturgeon is not designated in the Klamath River or its estuary. However, NMFS designated critical habitat for the near-shore area beyond an approximately one-mile area north, south, and offshore of the mouth of the Klamath River. The Proposed Action will not affect ocean conditions or any elements of sturgeon habitat outside of the Klamath River estuary.

Therefore, the Proposed Action will have no effect on southern DPS green sturgeon critical habitat.

See Appendix 9A for supporting information on species life history and biology.

9.2. Southern Resident DPS Killer Whale

The Proposed Action potentially affects Southern Resident killer whales to the extent that it alters Chinook salmon populations which could indirectly lead to a reduction in prey availability to the Southern Resident killer whale DPS. Reductions in the prey base may force killer whales to spend more time foraging, and could lead to reduced reproductive rates, slower growth rates, and higher mortality.

Chinook salmon from the Klamath River potentially affected by the Proposed Action likely constitute only a small portion of the Southern Resident killer whale prey base. Killer whales consume other prey (salmon, and non-salmonids) which originate from the Sacramento River, Puget Sound streams, and other coastal streams in Washington, Oregon, and California. Their wide-ranging migratory patterns put them in the proximity of numerous other Chinook salmon stocks originating from many coastal rivers and streams along the Pacific coast.

The portion of the coastal killer whale prey base that comes from the mainstem Klamath River affected by Project operations includes both wild and hatchery produced salmon, both ESA-listed and non ESA-listed groups. Klamath Basin Chinook salmon production contributing to the prey diet largely originates from the output of the Iron Gate Hatchery and Lewiston Hatchery on the Trinity River. Iron Gate Hatchery produces approximately 5.1 million Chinook salmon smolts and 900,000 yearlings each year (Reclamation 2011). Klamath Basin natural Chinook salmon runs, which are significantly reduced in size over historical levels, also may contribute to the killer whale diet. Lewiston Hatchery produces approximately 4.3 million Chinook salmon, consisting of 2 million fall Chinook smolts, 900,000 fall Chinook yearlings, 1 million spring Chinook smolts, and 400,000 spring Chinook yearlings each year.

Wild spring run Chinook salmon populations are reportedly a remnant of their historical abundance and primarily occur in the South Fork Trinity River and Salmon River Basins (NMFS 2011). NMFS (2011) indicates fall run Chinook in the last several decades have ranged from below 50,000 to 225,000 fish. Naturally produced (i.e., non-hatchery) smolt production is largely unknown, but has also dropped due to the significant decline in wild adult Chinook salmon runs over the last several decades.

As discussed in the Effects Analysis for coho salmon, the Proposed Action's effects on the Klamath River are concentrated in the reaches downstream of IGD and those effects decrease as the distance from IGD increases. Unlike coho, Chinook salmon primarily spawn and rear in mainstem rivers, so that part of the population that spawns and rears in the mainstem Klamath River is the population segment with greatest potential effect. Chinook salmon spawning in the mainstem Klamath River is estimated to have averaged 9,854 adults between 2001 and 2010 (Reclamation 2011). However, natural spawning is known to occur throughout the Basin and is not concentrated in these reaches. Most Chinook adults return to spawn between September and November. Klamath River releases at IGD can be somewhat reduced under the Proposed Action during periods of naturally occurring low base flows (generally July thru September) from Baseline conditions. Flow conditions below IGD will also remain somewhat reduced during the October thru March period when UKL re-fill occurs. Due to the Proposed Action, some reduced migration/spawning could occur during the early fall season. This potential effect to that fraction of the Chinook salmon population that migrates early and spawns in the mainstem reach closest to IGD may be reflected in some small, unmeasureable reduction in smolt numbers that out-migrate and the total population of Chinook salmon produced in the Klamath Basin that are available as Orca prey.

It appears, the Proposed Action will have potentially the greatest effect when the Southern Resident DPS is present and feeding on prey between Fort Bragg, California, and Florence, Oregon, in late winter and early spring. The Southern Resident DPS appears off the coast of California/Oregon irregularly and the frequency and duration of coastal visits during coastal migrations is not clear (NMFS 2008). The coastal area off the Klamath River is reportedly where the greatest concentration of Klamath origin Chinook salmon occurs (Reclamation 2011). The Klamath River stock is estimated to make up to 37 percent of the adult Chinook salmon off of Fort Bragg during the spring and up to about 45 percent off of the southern Oregon coast in July depending on (1) the inter-annual variability in strength of salmon runs, (2) the month, and (3) the location (Reclamation 2011). No information is available regarding ocean Chinook salmon stock composition during the winter months.

Chinook salmon impacts resulting from Project operations cannot be easily quantified with existing information. Potential impacts to wild Chinook salmon populations can potentially occur at any life stage from egg development and emergence, alevin and juvenile foraging, smolt emigration, and adult spawning. It is unknown to what extent the Proposed Action will have any effect on Chinook salmon which spawn and rear in the mainstem Klamath River. Chinook salmon production from Iron Gate Hatchery and Lewiston Hatchery greatly compensates for declines in many wild salmon populations and has likely benefited resident killer whales to some undetermined extent.

The Proposed Action’s impact to Klamath origin coastal Chinook salmon stocks is expected to be small and discountable relative to the overall hatchery production of Chinook salmon which contributes to the abundance of coastal salmon off southern Oregon and northern California. The Proposed Action small and discountable impact will also be offset by the availability of salmon prey originating from Puget Sound streams, coastal streams in Washington, Oregon, and California. Therefore, the potential loss of prey base that would occur due the Proposed Action cannot be meaningfully measured or detected. Reclamation concludes, therefore, that the Proposed Action may affect, but is unlikely to adversely affect the Southern Resident DPS killer whales.

See Appendix 9A for supporting information on species life history and biology.

9.3. Southern DPS Pacific Eulachon

Potential effects of the Proposed Action on this species would be limited to the lower Klamath River, estuary, and near-shore environment. This is because the southern DPS Pacific eulachon are only known to occupy the Action Area during the winter and spring for spawning, incubation, and early rearing. The Proposed Action and resulting downstream winter/spring flows in the lower Klamath River could affect southern DPS Pacific eulachon populations by impacting essential habitat features for spawning, incubation, and migration. Eulachon are documented to spawn in the lower Klamath River reach in association with spring freshets and rearing does occur in the estuarine and near-shore areas at the mouth of the Klamath River. Project operations, depending on hydrological conditions in a given year, can lower the volume of water in the Klamath River during times when the southern DPS Pacific eulachon is present. Lower water volumes may affect the quantity and quality of essential habitat features for spawning, rearing, and migration in particular water years. However, Project operations and resultant effects to flow in the lower Klamath River are not expected to significantly alter essential habitat elements for the southern DPS Pacific eulachon DPS, since the volume of water in the system in the winter/spring period is augmented by the many accretions of water from rivers and tributaries below IGD.

Therefore, Reclamation concludes that Proposed Action effects cannot be meaningfully measured or detected and may affect, but is not likely to adversely affect the southern DPS Pacific eulachon.

Critical habitat has been finalized in the lower Klamath River for the southern DPS Pacific eulachon.

The Proposed Action is not expected to alter the essential physical or biological features for migration and spawning that have been designated for the southern DPS Pacific eulachon. Therefore, the Proposed Action will have no effect on the designated critical habitat of the southern DPS Pacific eulachon.

See Appendix 9A for supporting information on species life history and biology.

Part 10 CONCLUSION

Reclamation has analyzed the effects of the Proposed Action (50 C.F.R. § 402.02) using the best scientific and commercial data available and has made the following effects determinations shown in the table.

Table 10-1. Determination of Effects.

Species	Scientific Name	Status	Effect of the Proposed Action
SONCC coho salmon	*Oncorhynchus kisutch*	Threatened	May affect, likely to adversely affect
Lost River sucker	*Deltistes luxatus*	Endangered	May affect, likely to adversely affect
Shortnose sucker	*Chasmistes brevirostris*	Endangered	May affect, likely to adversely affect
Southern Resident DPS killer whale	*Orcinus orca*	Endangered	May affect, not likely to adversely affect
Southern DPS North American green sturgeon	*Acipenser medirostris*	Threatened	May affect, not likely to adversely affect
Southern DPS Pacific eulachon	*Thaleichthys Pacificus*	Threatened	May affect, not likely to adversely affect
Critical Habitat	**Scientific Name**	**Status**	**Effect of the Proposed Action**
SONCC Coho salmon	*Oncorhynchus kisutch*	Designated	May affect, likely to adversely affect
Lost River sucker	*Deltistes luxatus*	Proposed	May affect, not likely to adversely affect
Shortnose sucker	*Chasmistes brevirostris*	Proposed	May affect, not likely to adversely affect
Southern DPS Pacific eulachon	*Thaleichthys Pacificus*	Designated	May affect, not likely to adversely affect

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